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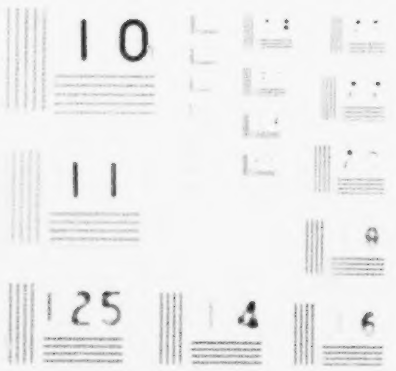
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REPORT RESUMES

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REORGANIZED SCIENCE CURRICULUM, 6C, SIXTH GRADE SUPPLEMENT.
MINNEAPOLIS SPECIAL SCHOOL DISTRICT NO. 1, MINN.
EDRS PRICE MF-$0.75 HC-$5.36 132P.

DESCRIPTORS- *ASTRONOMY, *BIBLIOGRAPHIES, *CURRICULUM DEVELOPMENT, *CURRICULUM, *CHEMISTRY, ELEMENTARY SCHOOL SCIENCE, GRADE 6, TEACHING GUIDES, BIOLOGY, EARTH SCIENCE, INSTRUCTIONAL MATERIALS, PHYSICAL SCIENCES, SCIENCE EQUIPMENT, SCIENCE MATERIALS, MINNEAPOLIS, MINNESOTA,

THE ELEVENTH IN A SERIES OF 17 VOLUMES, THIS VOLUME PROVIDES THE SIXTH GRADE TEACHER WITH A GUIDE TO THE REORGANIZED SCIENCE CURRICULUM OF THE MINNEAPOLIS PUBLIC SCHOOLS. THE MATERIALS ARE INTENDED TO BE AUGMENTED AND REVISED AS THE NEED ARISES. THIS VOLUME, 6C, IS ONE OF THREE COMPRISING THE SIXTH GRADE SUPPLEMENT, AND CONTAINS THE SECTIONS ON (1) BIBLIOGRAPHY, BOOKS, (2) BIBLIOGRAPHY, FILMS, AND (3) EQUIPMENT AND SUPPLIES. VOLUME 6A CONTAINS A RESOURCE UNIT RELATED TO CHEMISTRY, AND VOLUME 6B A RESOURCE UNIT FOR SPACE TRAVEL. (DH)

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OFFICE OF EDUCATION

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A SELECTIVE BIBLIOGRAPHY

of

BOOKS FOUND USEFUL

in the

TEACHING OF THE SCIENCE UNITS

for
Grade Six

Correlated to the Major Topics as found in the
Reorganized Science Curriculum

Minneapolis Public Schools
Science Department
8-24-64

For discussion purposes only Grade Six

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The annotations for books found on the following pages were obtained from many bibliographies which were consulted in the preparation of this list.

For discussion
purposes only

Grade Six

Introduction to Science

A. Attitudes (including history)	Tchr. Ref.	Illus.	Learning Activities	Pupil Interest	Reading Level
Gallant, Roy. 1958 EXPLORING CHEMISTRY ** Doubleday. $2.95 A good book on the development of chemical concepts.		X		Good	Average

* Good
** Excellent

[illegible] REFERENCE BOOK BIBLIOGRAPHY - Grade 6 - Addition to [illegible]
[illegible] Page 1

[illegible] Addition to [illegible]

A. [illegible]	[illegible]	Illus.	Learning Activities	Pupil Interest	Reading Level
Milgrom, Harry [illegible] [illegible] IN SCIENCE Dutton $3.00 The author describes [illegible] as a guide book to discovery [illegible] written to serve as a bridge between the wonder in the minds of children and the [illegible] of the world around them. It is a book of basic experiments.	*		*		

* Good
** Excellent

Introduction to Science

B. Tools	Tchr. Ref.	Illus.	Learning Activities	Pupil Interest	Reading Level
Beeler, Nelson F. and Franklyn M. Branley. 1957 EXPERIMENTS WITH A MICROSCOPE * Crowell. $3.50 Practical research ideas in many fields, and advice on the care and use of the microscope.	X	X	Good	Good	Average
Cosgrove, Margaret. 1959 WONDERS UNDER A MICROSCOPE ** Dodd. $3.00 An informal presentation of the hobby of microscopy, including clear descriptions of techniques and experiments.	X	X	Good	Good	Average
Epstein, Sam and Beryl. 1960 THE FIRST BOOK OF MEASUREMENT ** Watts. $2.50 Presents scales and devices by which the world does its measuring.		X	Average	Good	Average
Ford, Charles A., Editor-in-Chief. 1963 COMPTON'S ILLUSTRATED SCIENCE DICTIONARY * David-Stewart. $13.95	X				

* Good
** Excellent

Introduction to Science - B. (continued)

	Tchr. Ref.	Illus.	Learning Activities	Pupil Interest	Reading Level
Hamilton, Russell. 1960 SCIENCE, SCIENCE, SCIENCE * Watts. $2.95 A collection of outstanding writings by a variety of authors who present the lives and contributions of important men of science.				Good	Average
Herbert, Don. 1959 MR. WIZARD'S EXPERIMENTS FOR YOUNG SCIENTISTS ** Doubleday. $2.95 Contains experiments in numerous scientific areas, plus discussions of developments in each field.	X	X	Good	Good	Average
Shippen, Katherine B. 1962 A BRIDLE FOR PEGASUS * Viking. $3.50 Stories about people who wanted to fly beginning with Icarus who fell into the sea to the story of the steel rocket flying toward the stars.	X		Good	Average	Average

* Good
** Excellent

Introduction to Science

C. Methods	Tchr. Ref.	Illus.	Learning Activities	Pupil Interest	Reading Level
Barret, Raymond E. 1963 BUILD IT YOURSELF SCIENCE LABORATORY ** Doubleday. $4.50 This fully illustrated book tells you how to build 200 pieces of useful science equipment out of inexpensive materials for experiments and observations in chemistry, physics, and biology as well as in astronomy, geology, and meteorology.	X		Good		
Beeler and Branley. 1947 EXPERIMENTS IN SCIENCE * Crowell. $2.95 Home experiments with simple materials. Clear directions and illustrations.	X		Good		
Beeler and Branley. 1950 MORE EXPERIMENTS IN SCIENCE * Crowell. $2.95 Experiments with simple ingredients that give answers to many questions about helicopters, telegraph, stethoscopes, refrigerators, and numerous other things.	X		Good	Good	Average

* Good
** Excellent

Introduction to Science - C. (continued)

	Tchr. Ref.	Illus.	Learning Activities	Pupil Interest	Reading Level
Van Atta, Frieda E. 1962 HOW TO HELP YOUR CHILD IN GRADE SCHOOL SCIENCE * Random. $5.95 Grade-by-grade guide for parents prepared by a teacher.	X	X	Good	Good	Average
Vergara, William C. 1958 SCIENCE IN EVERYDAY THINGS ** Harper. $4.95 Answers to hundreds of interesting and scientific questions.	X				

* Good
** Excellent

SCIENCE RESOURCE BOOK BIBLIOGRAPHY - Grade 6 (Addendum)

Addition to Page 5

Introduction to Science

B. Tools	Teac. Ref.	Illus.	Learning Activities	Pupil Interest	Reading Level
Buchlitz, Ry 1963 DISCOVERING SCIENTIFIC METHOD ** Harper & Row $3.75 The important feature of this book is a series of photographs, each presenting problems to be solved through application of the scientific method. The author explains the basic procedures used by scientists and urges the readers to draw their own conclusions, but withholding the explanations and solutions which he provides.	*	*	Good	Average	Difficult

* Good

** Excellent

III. Energy

A. Properties of matter
related to energy

	Text. Ref.	Illus.	Learning Activities	Pupil Interest	Reading Level
Milgrom, Harry. 1960 MATTER, ENERGY AND CHANGE: EXPLORATIONS IN CHEMISTRY FOR ELEMENTARY SCHOOL CHILDREN ** Manufacturing Chemists Association. NC # (paper) Booklet of experiments emphasizing chemical principles, to aid elementary school teachers.			Good	Average	Average

* Good
** Excellent

III. Energy

C. Mechanical energy and simple machines	Tchr. Ref.	Illus.	Learning Activities	Pupil Interest	Reading Level
Buehr, Walter. 1962 THE FIRST BOOK OF MACHINES ** Watts. 2.50 A child's introduction to modern machinery.		X	Good	Good	Easy
Gottlieb, William P. 1959 JETS AND ROCKETS AND HOW THEY WORK ** Garden City Books. $2.75 Shows boys and girls step-by-step the basic elements of rocket propulsion.		X	Good	Good	Easy to Average
Cadmus, Dr. Robert R. 1961 THE CRAZY CANTILEVER ** Harper. $2.25 Fascinating and informative experiments easily performed with readily available materials. Designed to provide practice in careful observation, sound experimentation, and clear thinking.			Good	Good	Average

* Good
** Excellent

III. Energy - C. (continued)	Tchr. Ref.	Illus.	Learning Activities	Pupil Interest	Reading Level
Lewellen, John. 1953 BIRDS AND PLANES: HOW THEY FLY * Crowell. $2.00 Explanations of flight show that birds and airplanes both are kept in the air by the same principles.		X	Average	Average	Average
Liberty, Gene. 1960 THE FIRST BOOK OF TOOLS: The Story of the 12 Tools of Man ** Watts. $2.50 Shows children the basic types of tools, ancient and modern.		X	Good	Good	Average
Mann, Martin. 1960 HOW THINGS WORK * Crowell. $2.[illegible] Excellent descriptions of the fundamental nature of the modern mechanical devices, including the automatic transmission and [illegible].	X	X			
Meyer, Jerome S. 1962 ENGINES ** World Publishing Co. $2.[illegible] Explains principle of different engines to young boys.			Good	Good	Easy

* Good
** Excellent

For discussion
purposes only

III. Energy - C. (continued)	Tchr. Ref.	Illus.	Learning Activities	Pupil Interest	Reading Level
Meyer, Jerome S. 1958 MACHINES * World Publishing Co. $2.73 The wheel and axle, the lever, the screw and the wedge explained in easy-to-read or understand terms and clear black and white drawings.				Average	Easy
Munch, Theodore W. 1959 WHAT IS A ROCKET ** Benefic Press. $1.80 Excellent explanations of the workings of a rocket.		E	Good	Good	Easy
Pine, Tillie S. and Joseph Levine. 1960 FRICTION ALL AROUND * Whittlesey. $2.57 Shows youngest readers many examples of friction and the results.		E	Good	Good	Easy
Radlauer, Edward and Ruth Shaw. 1959 ABOUT MISSILES AND MEN * Melmont. $2.40 Shows youngsters how missiles are produced.				Good	Easy

* Good
** Excellent

For discussion
purposes only

III. Energy - C. (continued)	Tchr. Ref.	Illus.	Learning Activities	Pupil Interest	Reading Level
Schneider, Herman. 1950 EVERYDAY MACHINES AND HOW THEY WORK * McGraw. $2.96 "Simple, lucid text and more than 300 drawings explain the workings of many of the machines and devices encountered in the home..."			Good	Average	Average
Sharp, Elizabeth N. 1959 SIMPLE MACHINES AND HOW THEY WORK ** Random. $2.19 Shows how basic mechanical principles are exemplified in everyday life.		X	Good	Good	Easy
Stoddard, Edward. 1958 THE STORY OF POWER ** Garden City Press Books. $2.50 Diagrams of engines and motors in color. Gives ideas on the manner in which man may some day harness the hydrogen bomb.		X		Good	Average
Tannenbaum, Harold and Nathan Stillman. 1960 ROCKETS AND HOW THEY WORK ** Webster. 76¢ Explanations of principles of thrust, rocket shapes, and fuels.		X	Good	Good	Easy

* Good
** Excellent

III. Energy - C. (continued)	Tchr. Ref.	Illus.	Learning Activities	Pupil Interest	Reading Level
Tannenbaum, Harold and Stillman, Nathan. 1960 WE READ ABOUT AIRPLANES AND HOW THEY FLY ** Webster. 76¢ An easy-to-read book for even the very poor reader. Illustration and learning activities simple and clearly done.		X	Good	Good	Easy
Wells, Robert. 1962 WONDERS OF FLIGHT ** Dodd. $2.79 Describes in simple language the aerodynamics of thrust, lift, drag and speed.	X	X		Good	Average

* Good
** Excellent

SCIENCE RESOURCE BOOK BIBLIOGRAPHY - Grade 6
(Addendum)

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III. Energy

C. Mechanical energy and simple machines

	Tchr. Ref.	Illus.	Learning Activities	Pupil Interest	Reading Level
Herbert, Don & Ruchlis, Hy 1960 BEGINNING SCIENCE WITH MR. WIZARD: FLYING ** Doubleday $1.25 Contains information on what makes an airplane stay up, how airplanes, helicopters, and rockets work, and how to make paper planes that show the mysteries of flight.			Good	Good	Average
Zim, Herbert S. 1953 WHAT'S INSIDE OF ENGINES? * Morrow $2.60 Introduces the principles of operation of various types of engines. The elementary text is supplemented by a parallel text in smaller type meant to be read to the child by an adult.		I		Good	Average

* Good
** Excellent

III. Energy

F. Sound	Tchr. Ref.	Illus.	Learning Activities	Pupil Interest	Reading Level
Beeler, Nelson F. 1961 EXPERIMENTS IN SOUND ** Crowell. $2.95 Solid background information on the elementary physics of sound and acoustics, good descriptions of experiments for children, and suggestions for further reading. Winner of the 1961 Thomas A. Edison Foundation Award to the best science book for children.	X		Good		
Feravolo, Rocco V. 1962 WONDERS OF SOUND ** Dodd. $2.79 Explains sound with simple experiments for youhg children.			Good	Good	Average
Gould, Jack. 1953 ALL ABOUT RADIO AND TELEVISION ** Random. $2.37 Reveals the workings of radio and television in a manner understandable to all.		X	Good	Average	Average

* Good
** Excellent

III. Energy - F. (continued)	Tchr. Ref.	Illus.	Learning Activities	Pupil Interest	Reading Level
Irving, Robert (pseud. of Irving Adler). 1959 SOUND AND ULTRASONICS ** Knopf. $2.99 Includes sections on the nature and kinds of sound recording and transmitting and sounds we cannot hear. "A must have book." -- Teacher comment.		X	Good	Good	Average
Kadesch, Dr. Robert R. 1961 THE CRAZY CANTILEVER ** Harper. $3.95 Fascinating and informative experiments easily performed with readily available materials. Designed to provide practice in careful observation, sound experimentation, and clear thinking.			Good	Good	Average
Kettlekamp, Larry. 1956 THE MAGIC OF SOUND * Morrow. $2.78 There are four chapters entitled Producing Sounds, Capturing Sounds, Echoes and "Silent" Sounds, and Artificial Sound Effects. Many suggestions and clear drawings make it an excellent reference book for any beginning unit on sound and for the child who likes to experiment at home.		X	Good	Good	Average

* Good
** Excellent

III. Energy - F. (continued)	Tchr. Ref.	Illus.	Learning Activities	Pupil Interest	Reading Level
Knight, David C. 1960 THE FIRST BOOK OF SOUND * Watts. $2.50 A basic introduction to sound and its nature.			Good	Good	Average
Pine, Tillie S. and Joseph Levine. 1958 SOUNDS ALL AROUND * Whittlesey. $2.63 An elementary explanation of sound--what causes sound, how it travels, how it can be pitched high or low, softened, made louder, or stopped and how it can be used for fun. Suggests experiments which utilize materials found in the home.		X		Good	Average

* Good
** Excellent

III. Energy

J. Light and ultraviolet radiation

	Tchr. Ref.	Illus.	Learning Activities	Pupil Interest	Reading Level
Beeler, Nelson F. and Franklyn M. Branley. 1951 EXPERIMENTS IN OPTICAL ILLUSION ** Crowell. $2.95 The experiments will prove that seeing is not believing.	X	X	Good	Good	Average
Beeler, Nelson F. and Franklyn M. Branley. 1957 EXPERIMENTS WITH LIGHT ** Crowell. $2.95 A good introduction to the subject.	X		Good	Average	Average
Herbert, Don and Ruchlis, Hy. 1960 BEGINNING SCIENCE WITH MR. WIZARD: LIGHT * Doubleday. This book contains valuable information on how cameras, telescopes, and microscopes work, the nature of light waves, and how his eyes see.	X		Good	Good	Average

* Good
** Excellent

III. Energy - J. (continued)	Tchr. Ref.	Illus.	Learning Activities	Pupil Interest	Reading Level
Kadesch, Dr. Robert R. 1961 THE CRAZY CANTILEVER ** Harper. $3.95 Fascinating and informative experiments easily performed with readily available materials. Designed to provide practice in careful observation, sound experimentation, and clear thinking.			Good	Good	Average
Paschel, Herbert P. 1959 THE FIRST BOOK OF COLOR * Watts. $2.50 A brief and easy explanation of light and color.		X	Good	Good	Average
Ruchlis, Hy. 1960 THE WONDER OF LIGHT ** Harper. $3.27 An excellent book on the properties of light.			Good	Good	Average to Difficult

* Good
** Excellent

[illegible]	[illegible]	[illegible]	Learning Activities	[illegible]	Reading Level
Freeman, Ira M. 1965 ALL ABOUT LIGHT AND RADIATION ** Random House [illegible] Here is a clear, accurate information on the science of light, the radiation we can see, and the many kinds of radiation we can not see: X rays, ultraviolet rays, infra red rays, television waves. In this book, Dr. Freeman discusses both the scientific theory of radiation and practical applications of the expanding knowledge in this field. Included also are developments in lasers, radio astronomy and even "op art".	X		Good	Good	Average
Mayer, Jerome S. 1959 PRISMS AND LENSES ** World Pub. Co. $2.[illegible] Explains for young readers the principles of light and the practical application of prisms and lenses.	X	X		Good	Average
Tannenbaum, Harold & Stillman, Nathan 1960 TAKING PICTURES * Webster 69¢ This book contains a simple explanation of the importance of light and the use of various types of cameras in taking pictures.		X			Easy

* Good
** Excellent

III. Energy

L. Chemical Energy	Tchr. Ref.	Illus.	Learning Activities	Pupil Interest	Reading Level
Adler, Irving. 1955 FIRE IN YOUR LIFE ** Day. $3.50 Traces fire from early history through the phlogiston theory to its use in modern industry.	X			Average	Average
Freeman, Mae and Ira Freeman. 1944 FUN WITH CHEMISTRY ** Random. $1.95 A book of safe and entertaining experiments illustrating the basic principles of chemistry.		X	Good	Good	Average
Freeman, Mae and Ira Freeman. 1961 THE STORY OF THE ATOM ** Random. $2.19 In simplest terms tells children what atoms are and how scientists put them to work.				Good	Easy
Korn, Jerry. 1960 ATOMS: THE SMALLEST PARTICLES AND THE ENERGY THEY CONTAIN * Golden Press. $1.69 For young people.		X		Good	Difficult

* Good
** Excellent

III. Energy - L. (continued)	Tchr. Ref.	Illus.	Learning Activities	Pupil Interest	Reading Level
Lewellen, John. 1949 YOU AND ATOMIC ENERGY ** Children's Press. $2.00 Discusses Geiger counters, splitting atoms, and chained reactions. An excellent glossary of atomic terms is appended.	X	X		Good	**Average**
Mullin, Virginia L. 1961 CHEMISTRY FOR CHILDREN * Sterling Publishing Co. $2.99 Instructions for safe and easy experiments and projects plus explanations of the language, apparatus and techniques of chemistry.	X		Average		
Radlauer, Edward and Ruth Shaw (Radlauer). 1960 ABOUT ATOMIC POWER FOR PEOPLE * Melmont. $2.50 Of machines and scientists. 5th grade reading level.		X		Good	**Easy**

* Good
** Excellent

III. Energy

I. Chemical Energy

	Text Ref	Films	Learning Activities	Pupil Interest	Reading Level
Hecht, Selig 1959 EXPLAINING THE ATOM * Viking $3.95 Best popular explanation yet of the atom	I				
Lewellen, John 1955 THE MIGHTY ATOM * Knopf $2.59 What atoms are, how they form compounds, and how atomic energy is used to generate electricity and run engines.				Good	Average
Mitchell, Lane 1963 CERAMICS: STONE AGE TO SPACE AGE * Scholastic Book Services $2.63 In this volume in the "Vistas of Science" series, a ceramics engineer surveys his subject in a concise account of the materials and methods used in the manufacture of brick, pottery, glass, fire resistant materials, Portland cement, artificial gems, and some new ceramics products developed to meet the needs of the space age. Illustrative experiments, requiring the use of a kiln, but otherwise simple equipment are described. Information is clearly presented, but because of the technical nature of the subject and the author"s compact style, careful reading is required.	I		Good		

* Good
** Excellent

III. Energy [illegible] Continued	[illegible] Ref.	[illegible]	Learning Activities	Pupil Interest	Reading Level
Reinfeld, Fred (1963) PICTURE BOOK OF ATOMIC SCIENCE ** Sterling $1.99 In many pictures and explanatory text, Mr. Reinfeld, demonstrates what is happening in the world of atomic science. He describes the dramatic struggle that led to the discovery of uranium's importance, shows how fission and fusion can be made to occur, how reactors work, how the new element plutonium is man-made, how nuclear submarines and power plants have been constructed, how ingenious radioisotopes are revolutionizing medicine, creating new industrial fields, and changing our methods of agriculture. Wherever possible, he relates the discovery to its potential.	1				

* Good
** Excellent

IV. The Universe

F. Space Travel	Tchr. Ref.	Illus.	Learning Activities	Pupil Interest	Reading Level
Asimov, Isaac. 1960 SATELLITES IN OUTER SPACE ** Random House. $2.19 Facts about man-made satellites for the beginning reader.				Good	Easy
Beeland, Lee and Robert Wells. 1957 SPACE SATELLITE ** Prentice-Hall. $2.95 This book explains the launching of a satellite, how satellites stay in orbit, and what information we hope to gain from them.		X		Good	Average
Bergaust, Erik. 1961 ROCKETS TO THE PLANETS ** Putnam. $2.52 Outline of planned and imagined space vehicles.		X		Good	Difficult
Bergaust, Erik. 1959 SATELLITES AND SPACE PROBES ** Putnam. $2.52 A scientific study of the advances in space exploration and the prospects for the future.		X		Good	Average to Difficult

* Good
** Excellent

IV. The Universe - F. (continued)	Tchr. Ref.	Illus.	Learning Activities	Pupil Interest	Reading Level
Bizony, M. T. (ed.). 1957 THE SPACE ENCYCLOPEDIA: A GUIDE TO ASTRONOMY AND SPACE RESEARCH ** Dutton. $6.95 The background information one needs to understand the basic phenomena of the heavens and to prepare for its future exploration.	X				
Branley, Franklyn M. 1959 A BOOK OF MOON ROCKETS FOR YOU ** Crowell. $3.36 Informative picture book for young readers.		X	Good	Good	Average
Branley, Franklyn M. 1955 EXPERIMENTS IN THE PRINCIPLES OF SPACE TRAVEL ** Crowell. $2.95 "The purpose of this book is to enable the reader to differentiate between science and fiction, and to provide a sound frame of reference for those interested in space travel."	X		Good	Average	Average

* Good
** Excellent

IV. The Universe - F. (continued)	Tchr. Ref.	Illus.	Learning Activities	Pupil Interest	Reading Level
Caidin, Martin. 1960 THE ASTRONAUTS: THE STORY OF PROJECT MERCURY * Dutton. $3.95 Describes in detail the training program of the astronauts, for the general reader.	X			Good	Difficult
Coggins, Jack and Fletcher Pratt. 1958 ROCKETS, SATELLITES AND SPACE TRAVEL ** Random. $1.95 Many pictures enliven this book, which tells the history of rockets since the earliest Chinese inventions of 750 years ago up to today's possibility of travel to the moon.		X		Good	Average
Coggins, Jack and Fletcher Pratt. 1958 BY SPACE SHIP TO THE MOON ** Random. $1.00 Plans for the future are given, using the knowledge already amassed by today's scientists.		X		Good	Average
Coombs, Charles. 1960 PROJECT MERCURY * Morrow. $2.78 Information for young readers about America's man-in-space program.				Average	Average

* Good
** Excellent

IV. The Universe - F. (continued)	Tchr. Ref.	Illus.	Learning Activities	Pupil Interest	Reading Level
Del Rey, Lester. 1960 ROCKETS THROUGH SPACE * Winston. $3.95 An up-to-date view of space science.	X			Average	Difficult
Fenton, Carroll & Mildred. 1950 WORLDS IN THE SKY * Day. $3.29 This is a well illustrated book about the stars, planets and moon. The diagrams are very useful.		X		Average	Average
Freeman, Mae and Ira. 1953 FUN WITH ASTRONOMY * Random. $1.97 This book is well illustrated with photographs. It is easy to read, containing a minimum of details.		X	Average	Average	Easy
Gaul, Albro. 1956 THE COMPLETE BOOK OF SPACE TRAVEL * The World Publishing Co. $4.95 This interesting book was illustrated by Virgil Finlay. It includes an album of historical space travel art prepared by Sam Moskowitz. This book will serve as an introduction to the facts and problems of space travel, an era that is predicted by many in the not-too-distant future.	X				

* Good
** Excellent

IV. The Universe - F. (continued)	Tchr. Ref.	Illus.	Learning Activities	Pupil Interest	Reading Level
Goodwin, Hal. 1954 THE REAL BOOK ABOUT STARS * Garden City Books. $1.95 This is a detailed book for youngsters about the astronomical bodies. It contains very good charts of the moon and other objects. It has a reading level of grades 5 - 8.	X				
Hendrickson, Walter B. 1960 HANDBOOK FOR SPACE TRAVELERS * Bobbs. $3.95 History of rockets, and current and future space programs, for young people.	X				
Hendrickson, Walter B., Jr. 1961 PIONEERING IN SPACE * Bobbs. $3.50 Elementary introduction to the U.S. space program, for younger boys.				Average	Average
Hyde, Margaret O. 1957 EXPLORING EARTH AND SPACE * McGraw-Hill. $3.00 This is a good book with a reading level of grade 4 - 7.		X		Good	Average

* Good
** Excellent

IV. The Universe - F. (continued)	Tchr. Ref.	Illus.	Learning Activities	Pupil Interest	Reading Level
Lawrence, Mortimer W. 1960 THE ROCKETS' RED GLARE: CHALLENGE OF OUTER SPACE ** Coward-McCann. $2.95 Shows young people why rockets work, and how we prepare for space flight.	X		Good	Good	Average to Difficult
Lewellen, John B. 1953 YOU AND SPACE NEIGHBORS * Children's Press. $2.00 An entertaining and informative book about our neighbors in space. Attractive drawings will appeal to children.	X			Average	Average
Lewellen, John B. 1951 YOU AND SPACE TRAVEL * Children's Press. $2.00 Easy reading and amusing sketches in both books will attract young readers who want more information about propellers, jet planes, helicopters, rockets, and space travel.	X			Average	Difficult
Ley, Willy. 1958 THE CONQUEST OF SPACE ** Viking. $5.75 Describes the launching of a giant rocket, relates the history of rocket flight, and speculates about its future.	X	X		Good	Difficult

* Good
** Excellent

IV. The Universe - F. (continued)	Tchr. Ref.	Illus.	Learning Activities	Pupil Interest	Reading Level
Ley, Willy. 1958 MAN-MADE SATELLITES ** Simon & Schuster. $2.25 For young readers.		X		Good	Average
Moore, Patrick. 1956 THE BOY'S BOOK OF SPACE * Roy Publishers. $2.75 The possibilities of space travel of trips to the Moon, to Venus, and Mars are no longer a dream but a reality. Here is the most up-to-date and enthralling information on how and when this will be possible.	X	X		Good	Difficult
Nephew, William and Michael Chester. 1960 BEYOND MARS * Putnam. $2.68 Missile experts describe in simple language for boys and girls the difficulties and problems a trip to one of the outer planets would entail.		X	Good	Good	Average
Ruchlis, Hy. 1958 ORBIT: A PICTURE STORY OF FORCE AND MOTION * Harper. $2.92 This is a well written, illustrated book related to flight and space which shows Newton's Laws of Motion in action.	X	X	Good		

* Good
** Excellent

IV. The Universe - F. (continued)	Tchr. Ref.	Illus.	Learning Activities	Pupil Interest	Reading Level
Shelton, William Roy. 1963 FLIGHTS OF THE ASTRONAUTS ** Little, Brown. $3.75 An eyewitness report of the first four Project Mercury flights from preparation to recovery with brief biographies of Shepard, Grissom, Glenn, and Carpenter.			Average	Good	Average
Slobodkin, Louis. 1952 THE SPACE SHIP UNDER THE APPLE TREE * MacMillan. $3.00 This is an amusing story of an average boy who had many questions in his head concerning space travel.				Good	Average
Spilhaus, Athelstan. 1958 SATELLITE OF THE SUN ** Viking. $3.50 An excellent teacher or student reference. Illustrated with black and white photographs.	X				
Terence, Kay. 1960 SPACE VOLUNTEERS * Harper and Brothers. $2.92 This book contains interesting information about research on problems related to manned space travel.	X			Good	Average

* Good
** Excellent

IV. The Universe - F. (continued)	Tchr. Ref.	Illus.	Learning Activities	Pupil Interest	Reading Level
Wells, Robert. 1960 ALIVE IN SPACE: THE SCIENCE BIO-ASTRONAUTICS * Little. $3.75 Discusses for young people space instruments, weightlessness, living in space and training for space.			Average	Good	Average to Difficult
White, Anne Terry. 1953 ALL ABOUT THE STARS ** Random. $1.95 This book contains much information about astronomy and includes a chapter on what life there may be on Mars. The reading level is grades 4 - 9.		X		Good	Average

* Good
** Excellent

SCIENCE RESOURCE BOOK BIBLIOGRAPHY - Grade 6
(Addendum)

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IV. The Universe

F. Space Travel	Tchr. Ref.	Illus.	Learning Activities	Pupil Interest	Reading Level
Coggins, Jack & Pratt, Fletcher 1958 ROCKETS, SATELLITES AND SPACE TRAVEL ** Random House $1.95 Many pictures enliven this book, which tells the history of rockets since the earliest Chinese inventions of 750 years ago up to today's possibility of travel to the moon.	X	X		Good	Average
Coombs, Chas. I. 1957 ROCKETS, MISSILES AND MOONS * William Morrow $3.75 This book has good discussion of methods of transportation beyond earth's surface and what we may hope to discover when man reaches moon. The illustrations are good. The reading level of this book is grades 3 - 6.	X	X		Good	Average

* Good
** Excellent

SCIENCE RESOURCE BOOK BIBLIOGRAPHY - Grade 6
(Addendum)

Addition to
Page 27

IV. The Universe - F. (continued)	Tchr. Ref.	Illus.	Learning Activities	Pupil Interest	Reading Level
Haggerty, Jr., James J. 1962 SPACECRAFT ** Scholastic Book Services 50¢ With Project Apollo, American scientists will put a three-man team on the moon and bring it safely home again. To carry out this and other momentous achievements, the National Aeronautics and Space Administration is designing, building, and testing a succession of space probes and satellites. This book takes you to the laboratories and the launching pads where NASA scientists and engineers are exploring the problems of man's future in space.	X	X	Good	Good	Average
Pacilio, James V. 1965 DISCOVERING AEROSPACE * Childrens Press $4.50 The dramatic story of flight from balloons to spaceships. Simple experiments add to the excitement of learning and discovery, and show the principles of lift, thrust, gravity, drag, etc. A book to encourage young scientists to question, observe, discover and understand the concepts related to aerospace.			Good	Good	Average to Difficult

* Good
** Excellent

[illegible]	[illegible]		[illegible]	Pupil Interest	Reading Level
[illegible]				Good	Diffi-cult

[illegible]
= Excellent

Grade Six

BASIC SCIENCE EDUCATION SERIES
Published by Row, Peterson & Co.

(Grade Placed for Major Topic in the Reorganized Science Curriculum)

	Reading Level
Introduction to Science	
A. Attitudes (including history)	
The Scientist and His Tools	4.5
Superstition or Science	5.8
B. [illegible]	
The Scientist and His Tools	4.5
Superstition or Science	5.8
C. Methods	
The Scientist and His Tools	4.5
Superstition or Science	5.8
III. Energy	
A. Properties of matter related to energy.	
Matter, Molecules and Atoms	5.6
C. Mechanical energy and simple machines.	
Machines	3.2
F. Sound	
Sound	4.7
J. Light and ultraviolet radiation.	
Light	4.5
L. Chemical energy	
Matter, Molecules and Atoms	5.6
What Things are Made Of	4.3

JLP/db
10/18/67

BIBLIO. - FILMS

For discussion purposes only

A PARTIAL LISTING OF PRESENTLY OWNED

SCIENCE MOTION PICTURE FILMS

GRADE SIX

Correlated to the Unit Titles as found in the
Reorganized Science Curriculum

Minneapolis Public Schools
Science Department
12-1-64

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Major Topic	Page Number	Color
Introduction to Science	1	Gray
A. Attitudes B. Tools C. Methods		
III. Energy		
A. Properties of matter related to energy	3	Yellow
L. Chemical energy	6	Yellow
C. Mechanical energy and simple machines	9	Yellow
F. Sound	15	Yellow
J. Light and ultraviolet radiation	17	Yellow
IV. The Universe		
A. Space travel	21	Blue

The annotations for films found on the following pages were obtained in most cases from the Library of Congress cards. Some annotations were secured from other sources such as the Educational Film Guide and producers' catalogs.

Introduction to Science

A. Attitudes (including history)

B. Tools

C. Methods

Name and Description of Film	Other Grade Placements	Remarks
1. Horizons Beyond * Bell Tele. Co., 1958; 12 min., color Illustrates the impact of scientific research on everyday life. Surveys the inventions at the Bell Telephone Laboratories ranging from the transistor to a new over-the-horizon microwave radio system. Explains the contribution of the transistor to every electronic field. Shows Bell Telephone scientists at work on research projects using temperatures near absolute zero, exploring beyond the limits of vision, and seeing molecules; describes the development and use of the over-the-horizon system, which was first used with the Arctic defense networks.	Gr. 11 - **	
2. *How to Measure Time* * EBF, 1961; 10 min., color A boy discovered that when he is bored, time moves slowly, but when he is excited, time goes by rapidly. We examine a pendulum clock, a wrist watch, the boy's heart beat, the rythm of a jazz combo, the earth's circling the sun, the earth turning on its axis as periods of time. The stop watch is used to time a high hurdles race and electronic timers are introduced.	Gr. 3 - ** Gr. 5 - **	

* Good
** Excellent

How To Measure Time

Film Summary

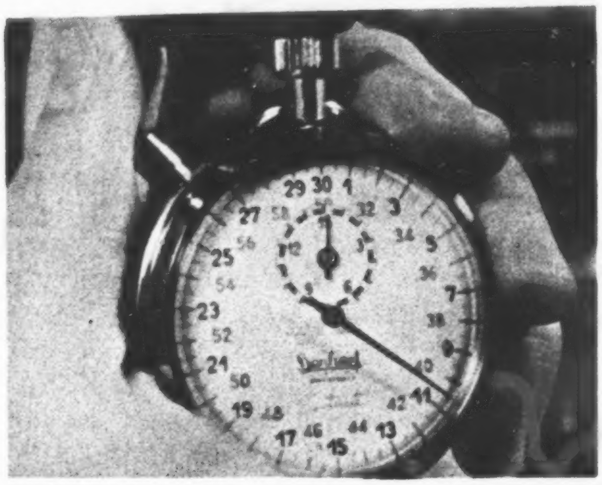
We see actors moving on a stage. What would happen if we could stop time? The actors freeze in grotesque positions. If there were no time, nothing would happen, nothing would change. Of course, no one can stop time. It just keeps rolling along. The actors unfreeze and continue with the action of the play.

A bored boy sits with the audience in a recital hall. When you are bored, time seems to pass slowly. Now the boy is racing toward second base, sliding in safely ahead of the throw. When you are having fun, time can pass so quickly, you hardly notice it's going by. And the boy is surprised, standing on second base, by his mother, insisting that he is late for supper. To measure time accurately, you need to count it. But how do you count something you cannot see or feel or hear?

Now, a boy and a girl measure the amount of time it takes to ride a bicycle once around a house. The measurement is made by measuring a steady flow of water. In the time it takes to ride once around the house, the girl can fill two and a half glasses from the flow of water. The boy and girl have made a crude sort of clock. A clock is simply a device that repeats something over and over again—like filling a glass with water. By counting the number of times the action is repeated, we count time.

Now we look at more elaborate clocks. First, a pendulum clock. The repeating action is the swing of the pendulum. Next, a wrist watch. The repeating action here is the pulsing of a spring back and forth.

We hear the boy's heartbeat through a stethoscope, and here, again, is a kind of clock. The repeating action of the heartbeat may be what gives man a built-in sense of time and rhythm. The musicians of a jazz combo demonstrate how this built-in sense of time and rhythm is used to measure very short intervals of time.



In animation we see the earth circling the sun, and notice that here, also, is an action being repeated. The earth moving around the sun is a kind of clock that measures time in periods of one year. The earth turning on its axis is another clock that measures time in periods of one day.

The high hurdles are timed with a stop watch. It is quite obvious that it is handy to have clocks that measure time in periods shorter than a day. There are clocks that can measure very short periods of time; for example, the time it takes a flashbulb to flash.

We see an oscilloscope being used as a clock. The oscilloscope, like other clocks, repeats an action. A spot moves across its screen at a regular rate. An electric eye is attached to the oscilloscope. By flashing the flashbulb into the electric eye, and observing the line traced on the screen of the oscilloscope, we can measure the amount of time it takes for a flashbulb to flash.

Introduction to the Film

There are three important things we measure in physics. They are mass, length, and time. The importance of time in our lives is attested to by the fact that most of us carry watches. Very few of us carry a tape measure to measure length or scales to measure mass, but almost all of us carry a watch to measure time. If you ask anybody just what time *is,* you will find it difficult to get an answer. It is not an easy question and even people who know a great deal about the science of time would find it difficult to answer. Yet the very fact that we all carry watches indicates that we can measure time even if we don't know what it is.

Even without a watch we "feel time go by." Alone and in the dark we might lose our sense of space and orientation, but some sense of time prevails. Maybe it's because we breathe or because our hearts beat in a rhythmical way. The exact cause is not well understood, but it is a curious fact that some people can awaken at will at a predetermined hour without the help of a clock. Many animals seem to have a time sense. Biologists have observed a certain kind of slug that starts laying its eggs around the first of August even when kept for a whole year in an artificial laboratory environment.

Human beings seem to have the following intuitions and abilities related to time:

1. We have a feeling that time flows without interruptions or breaks.
2. We can put past events in their proper order in our memory.
3. We can estimate very crudely the magnitude of a time interval between events.

The last is the hardest thing to do accurately. We cannot really rely on our sense of time to measure the interval of time between two events with any accuracy at all. Man has developed devices and made use of natural occurrences to help him measure time more accurately. Anything that can measure time is a clock. Clocks have one thing in common. They repeat an action over and over again. And by counting the number of times they repeat the action, we count, or measure, time.

Finally, although we can talk about time and space as if they were abstract and separable things, what we are really interested in is "events." The birth of a child is an event. Notice how it is heralded. The time and place are given. The weight and size of the baby are recorded. In other words, mass, length and time are required to describe this "blessed" event. The collision between two cars is an event. The eclipse of the sun is an event. The disintegration of an atomic nucleus is an event. If you can give answers to the questions "What, Where, and When" about something, it is an event. It is the part time plays in the description of events that makes it an important scientific concept.

Demonstration To Be Presented Before Showing the Film

From the word "go," have a group of students count up to ten seconds, each one counting quietly to himself. Have each one raise his hand when he has counted ten seconds. It is very unlikely that the hands will go up together. Mention the trick of counting "a thousand one . . . a thousand two . . . a thousand three . . ." as a means of lengthening the interval so that it approximates one second. Have the students count this way and check them with a watch to see how accurate they are. Is this counting a kind of clock? What is a clock?

Experiments and Projects

1. With a stop watch or just by looking at an ordinary electric clock with a second hand, find out how long it takes for your heart to beat sixty times. You can do this by feeling your pulse and counting. Repeat the measurement several times to see if it comes out about the same. Now run 100 yards at a pretty fast pace and time your heartbeat again. Is the heartbeat a very accurate clock?

2. Two students can do this experiment in *reaction time* if they have a yardstick and a wall. One student holds the yardstick up by pressing it against the wall. Without telling the other student, he suddenly lets the yardstick fall. The second student stops the yardstick as quickly as he can by pressing it against the wall. The distance the yardstick fell is a measure of the second student's reaction time. Do it several times to see if the reaction time remains about the same or improves. Have the two students

trade places and measure the first student's reaction time. Someone with very quick reaction time will not permit the yardstick to drop very far.

3. Let a thin stream of water flow from a tap and find out how long it takes for the stream to fill a glass of a certain size. Repeat this experiment several times and, using a watch, measure the length of time required to fill the glass each time. Does it always come out the same? If it does not, explain why you think it does not.

4. A "seconds" pendulum is one that "ticks off" seconds. That is, it takes one second to swing from one side to the other. Make a pendulum one meter long (39.37 inches). A pendulum one meter long should "tick off" seconds. Set the pendulum vibrating and time sixty swings. Did it take one minute? If not, adjust the length of the pendulum slightly, and time it again.

If you double the length of the pendulum, what effect will it have on the time it takes to swing? Try it and see. Leaving the length of the pendulum unchanged, substitute a much heavier weight. Time the vibrations of this pendulum. Does changing the heaviness of the weight change the length of time it takes the pendulum to make a swing? Your experiment should indicate that it does not.

Swing the same pendulum over large and small arcs. By timing the swings, determine whether the size of the arc has anything to do with the time of swing. (Providing the arc length is not excessive, it should not.)

5. How does a wrist watch work? Read about clocks in the *Encyclopaedia Britannica, Jr.* Watches have something in them that vibrates regularly and something else that can count the vibrations. Look up the names of the parts that serve each of these functions. If you have an old watch, examine its works with a magnifying glass and see if you can locate these parts.

6. Go to a spot which is in the sun all day and drive a stick into the ground. Observe the position of the shadow of this stick at different hours of the day. Of course the shadow should be long in the morning and in the evening, and there should be a time when the shadow is shortest. Try to locate the position of the shadow when it is shortest and draw a line on the ground that corresponds to it. Record the time on your watch when the shadow falls on this line. Now come back approximately 24 hours later and once again record the time on your watch when the shadow is shortest. Have you made a clock? What is the action that is being repeated? Is it the turning of the earth around its axis? This experiment will not give you very accurate results, but it illustrates what is meant by solar day. A solar day is the time from one noon to the successive noon. Read about solar time in the encyclopaedia and find out whether all solar days are the same length.

7. Tape a soda straw to a fence post so that it is rigid, and so that it is aimed in such a way that you can sight through it and see a single star. Record the time on your watch when the star could be sighted through the soda straw. Repeat the same observation the following night about 24 hours later. Record the exact time on your watch when you can see the same star through the soda straw. The interval of time between these two sightings is called a sidereal day. All the important experiments done by astronomers are run on sidereal time. The turning of the earth on its axis in relation to the stars is the clock that measures time in periods of sidereal days.

8. Using the *Encylopaedia Britannica* as a reference, draw a scale model of the solar system and find out how long it takes for each of the planets to make a revolution around the sun. How is one year defined? Find out how many seconds there are in one minute, in one hour, in one day, and in one year. How long does it take the moon to complete one cycle from one full moon to the following full moon?

9. Get a metronome or something that ticks off seconds loudly, and have a student walk along the blackboard as the metronome ticks, drawing a line on the blackboard as he walks. Is there a point on the line that

represents 3½ ticks? 3¼ ticks? 3.2 ticks, etc.? This line represents distance but it also represents time. To show this, have the student go back to the starting position and this time, as the metronome ticks off seconds, zero, one, two, three, etc., and as the student walks along the blackboard, have him make a vertical mark on the blackboard each time the metronome ticks. Measure the distance between these lines with a ruler. Was the student walking at a constant speed? Is the student moving along the blackboard in any way like the dot moving across the screen of the oscilloscope seen in the film?

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III. Energy

A. Properties of matter related to energy

Name and Description of Film	Other Grade Placements	Remarks
1. Air All Around Us * Young America, 1948; 10 min., black & white Explains the properties of air by demonstrating that air is a substance which exerts pressure, expands and contracts, and can be compressed.	K - ** Gr. 4 - ** Gr. 7 - **	Adv.
2. Atomic Energy--Inside the Atom ** EBF, 1961; 13 min., color Visualizes in animation the structure of the atom; shows in demonstrations involving the cloud chamber and the Geiger counter, the power of the atom, and observes its uses in a hospital, an atomic power plant, and an atomic submarine.	Gr. 9 - **	
3. Evidence for Molecules and Atoms ** EBF, 1961; 19 min., color Uses simple experiments to reveal that even though we cannot see them, atoms and molecules exist. The experiments also show that circumstantial evidence is a very valuable tool in scientific research.	Gr. 9 - **	
4. Explaining Matter: Molecules in Motion ** EBF, 1959; 11 min., color Describes solid, liquid and gaseous states of matter by means of molecular theory. Explains the movement of molecules in each state, and discusses the physical change of state in terms of molecular motion. Presents pressure as an aspect of molecular motion.		

* Good
** Excellent

Energy - A. (continued)

Name and Description of Film	Other Grade Placements	Remarks
5. Simple Changes in Matter * Coronet, 1953; 11 min. School students learn the difference between chemical and physical change and observe the changes in simple matter as evidenced in soil erosion, metal expansion, ice melting, leaves changing color, and logs decaying.		
6. Understanding Matter and Energy ** Int'l Film Bureau, 1962; 18 min., color In a fascinating film technique, the "conversation" a boy has with a narrator leads to a thorough demonstration of the physical properties of matter in its solid, liquid or gaseous state. Animation clarifies the molecular action of matter while it is a solid, liquid or gas. The concept that matter may be transformed into energy and that these sources of energy, heat, chemical, mechanical, light, electrical - are utilized to serve man is also shown.	Gr. 5 - * Gr. 9 - **	
7. The World of Molecules ** Churchill-Wexler, 1959; 11 min. Presents an introduction to molecular movement in solids, liquids, and gases. Shows two boys experimenting with ink in water, doughnuts and air, and sand and water. The changes of matter from solid to liquid, liquid to gas, gas to liquid, and liquid to solid are also discussed.		

* Good
** Excellent

Atomic Energy—Inside The Atom

Film Summary

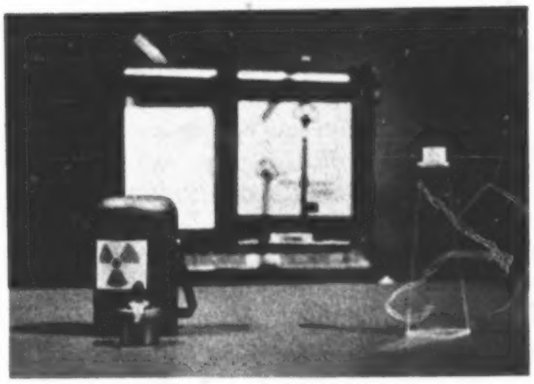
White streaks radiate out from a central point. These streaks, somewhat similar to the vapor trails left by high-flying airplanes, are being made in a cloud chamber by pieces of atoms. The cloud chamber we see is a simple one, built from a small thermos bottle. The source of the streaks is a bit of luminous watch dial. Some of the atoms that make up the luminous paint are breaking up and throwing out tiny pieces in all directions. These fast-moving pieces of atoms make the vapor trails.

When the same bit of watch dial is brought close to a Geiger counter, the counter clicks violently. The same pieces of atoms that are thrown out and make the vapor trails seem to carry with them something that makes the Geiger counter click.

In an animated sequence, we see a diagram of an atom. Of course, no one knows what an atom looks like. But the evidence gathered from many experiments indicates that atoms apparently have certain parts. There is a central core called a nucleus, and most of the material of the atom is concentrated in this core, even though the core is only about one ten-thousandth the diameter of the entire atom. In an atom of a radioactive material this core or nucleus seems to be unbalanced in some way. The unbalanced nucleus of a radioactive atom tends to throw out some pieces of itself, and when these pieces are thrown out, if certain conditions are just right, we see the vapor trail in the cloud chamber, or hear the click in the Geiger counter.

A common wrist watch, if it has the kind of dial that shines in the dark, may be radioactive, and can make a Geiger counter click. But a wrist watch can be checked for radioactivity without using a Geiger counter. All you need is a magnifying glass. Take the wrist watch and the magnifying glass into a completely dark room. Wait for about 15 minutes until your eyes become sensitive to a very faint light. Then look at one of the numbers of the luminous dial of the watch through a magnifying glass. In an animated sequence we see what you will see through the magnifying glass. Random flashes emanate from all parts of the luminous number. Each flash is caused by the nucleus of one radioactive atom throwing off a little piece of stuff at high speed.

There are many materials in nature that are naturally radioactive. We see a team of uranium prospectors prospecting in the desert. Using a Geiger counter, they locate an outcropping of rock that apparently contains some naturally radioactive material.



We look closely at four small wafers of metal. A Geiger counter indicates that the metal wafers are not radioactive. The wafers are placed inside a metal tube which, in turn, is placed inside a larger metal container. This container is carried into a building which houses a nuclear reactor. Inside the building, the metal container is lowered into the reactor itself. When the container is removed from the reactor several hours later, everything inside it is so radioactively hot that it can be handled only by remote control.

Man-made radioactive materials may be used in a hospital to treat cancer patients. The man-made radioactive material in the hospital does work. Radiation can do work because radiation carries energy.

In an atomic power plant, energy from radioactive atoms is used to generate electric power. An atomic submarine submerges under an icecap near the North Pole. Energy from radioactive atoms can send this submarine several times around the world without refueling. An envelope containing photographic paper can be affected by energy in the form of light. A large metal key is hung in front of the envelope, and then a radium source is placed several feet away. Several hours later the radium source is returned to its lead container. When the photographic paper is developed, we see that it has been exposed everywhere except where it was protected from the radioactive source by the metal key. Energy from radioactive atoms exposed the paper.

Introduction to the Film

Not only do we believe today in atoms and molecules which are invisible, but good evidence has also led us to believe that inside each atom there is a nucleus which is about 10,000 times smaller than the atom itself. The first bits of evidence indicating this came from certain unstable atoms which we call radioactive.

These radioactive atoms disintegrate spontaneously in a random way. If it is impossible to see atoms and molecules, it is clearly impossible to see the nucleus of an atom. Yet there are ways of making the effects of the nuclei of radioactive atoms visible.

The air we breathe is invisible. The air we exhale is usually invisible, too, but on a cold clear day you can sometimes "see your breath." In fact, if you blow your breath into a home food freezer you will see what looks like smoke but what is actually the moisture in your breath. Under certain conditions of pressure and temperature, moisture will condense even on single atoms, in much the same way moisture can condense on much larger objects such as a cold drinking glass, for example.

When a radioactive atom disintegrates, tiny particles are thrown out from its nucleus. As these particles shoot out from the nucleus of the radioactive atom at a very high speed, they affect surrounding atoms of material in such a way that these atoms can condense a vapor. We can see this condensation, and, in this way, the radiation which comes from inside the nucleus of a radioactive atom can indirectly be made visible.

Using a cloud chamber, the film shows the condensation tracks made by alpha particles as they speed away from the nuclei of the radioactive atoms of an ordinary luminous watch dial. The cloud chamber is simply a gadget that supplies the proper sort of atmosphere for the condensation to take place. There is always radiation coming from the nuclei of radioactive atoms. The cloud chamber does no more than to make this radiation indirectly visible. A Geiger counter is another device that permits us to "see" (in this case, hear) and measure radiation. Whenever radioactive atoms are present, there is radiation. The Geiger counter can tell us it is there, and can tell us how much of it there is.

No attempt is made in this film to explain what radiation is or what causes it. The film does not discuss the interior make-up of atoms, radioactive or nonradioactive. The intent here is to present several pieces of evidence to suggest that the atom is not an entity in itself; that there is something inside the atom. The film goes on to demonstrate that there is energy inside the atom, showing several examples of this kind of energy doing work.

It is most important for the students to understand clearly that the animated sequences included in the film are in no way meant to be representational. It is indeed true that no one knows what an atom looks like. The animated sequences are diagrammatic and are intended only to suggest that atoms have parts; not to represent what these parts look like or how they are located in respect to each other.

Of the experiments in the film—the several pieces of evidence suggesting that there is something inside the atom—the easiest to duplicate is the experience of examining a luminous number on a watch dial through a magnifying glass in the dark. Every teacher and student can and should have this opportunity of seeing for himself this strong piece of visual evidence suggesting that something is going on inside radioactive atoms. The animated sequence in the film, which demonstrates what you should see after your eyes have become adjusted to the very faint light, can be no more than an approximation. This is something that you must see for yourself.

It is not difficult to build a cloud chamber of the kind used in the film. (See EXPERIMENTS AND PROJECTS, No. 6.) Geiger counters are expensive, but they are becoming more easily available. It is entirely likely that your local fire or police department will have one for Civil Defense purposes. Geiger counters are extremely simple to operate and are not dangerous. If it is possible to borrow one and bring it into the classroom, it can be used in many very simple, yet extremely valuable, experiments.

Demonstration To Be Presented Before Showing The Film

Have a luminous watch dial available. Use it as a focal point to raise some questions. For example, what makes it light? Is the light on all the time, or is it off part of the time? Does it take energy to make the dial light in the dark? Where does that energy come from?

If a Geiger counter is available, especially the kind that clicks as it counts, bring the watch dial close to it and observe the intermittent signals you get. Do you think that the light from the luminous dial is also intermittent? Does it take energy to make the Geiger counter click? (We leave these as open-end questions because they will be answered in the film.)

Experiments and Projects

1. The luminous watch dial viewed under a magnifier is one demonstration that all students should see. But it is difficult to show in a class. The dark adaptation takes between ten and fifteen minutes and must be done in a perfectly dark room. Therefore, a room at home and probably at night, is indicated. You want to be sure that the luminous dial is luminous primarily due to radioactive disintegration and not due to the phosphorescence which lingers after the luminous dial has been exposed to sunlight. We are interested in the effects that linger long after the exposure to sunlight.

Take the watch or clock and a ten-power magnifier into a room which can be made absolutely dark. There must be no light at all. A closet or basement room will often work. If it is after dark, there will be less chance of light leaking into the room through cracks. Now you will have to wait in the dark for at least ten minutes. Keep your eyes open. After ten minutes, try looking at one of the luminous numbers through the magnifying glass. You should see many brilliant short flashes. Each of these flashes means that the nucleus of one radioactive atom has broken up and thrown out something. When this stuff, or radiation, hits the phosphorescent paint with which the number is coated, it makes a glow. And you see a flash. The number of flashes indicates that a great many atoms are breaking up; yet this will go on for many years. An indication, certainly, that it takes a tremendously large number of atoms to make up a very small amount of material.

2. An atom is about 10,000 times larger than its nucleus. If you drew a circle one foot in diameter to represent the nucleus, the atom would be 10,000 times bigger than that. Now a mile is a little over 5,000 feet. Ten thousand feet is very close to two miles. Imagine a circle with a diameter of two miles. That would be the scale of an atom if its nucleus were drawn with a diameter of one foot. Ask a student to draw two circles, one of which is 10,000 times larger than the other. The small circle will have to be very small indeed if you intend to draw both circles to scale. (The inner circle will have to be no bigger than the smallest dot you can make with a pencil in order for the large circle to stay inside the classroom.)

3. If a Geiger counter is available, observe the effect of bringing a luminous watch dial close to it. A good exercise is to put the watch dial sufficiently far away from the Geiger counter so that only a few clicks per minute can be counted. Count the number of clicks in one minute. Repeat again for another minute. Be sure to leave the watch dial in the same place. Do this several times. Do you get about the same number of clicks per minute at each trial?

NOTE: Even when there is no radioactive source nearby, the Geiger counter will click occasionally. These clicks are caused by cosmic rays and by other background radiation that is always present.

4. Divide the class in half. Ask half the class to leave the room or to close their eyes This half of the class will be given the Geiger counter. Ask the other half of the class to hide the watch which is being used as the radioactive source. When the watch is hidden, the students with the counter can search for it.

Using the Geiger counter to search for a radioactive object should be fun, but it is also instructive. Prospecting for deposits of natural radioactive material is normally done with a counter. More important, this is the way the path of radioactive materials introduced into living organisms is followed through the organism. Tracing the path of a material through a human body, for example, is often done today in medicine by including some radioactive atoms with the material, and keeping track of their location inside the body with a radiation counter. (The more sensitive scintillation counter has practically superseded the Geiger counter.)

5. Place the watch at a distance far enough from the Geiger counter so that the counter clicks at a moderate rate. Now wrap the watch in different materials to see if these materials will stop the particles being thrown off from the nuclei of the radioactive atoms. If you are successful in stopping them, the counter will, of course, stop clicking. Try paper first. If one sheet is not enough, try two. And so on. Try aluminum foil, wood, sand, bricks. Are you ever successful in stopping all the radiation? Can you stop part of it?

6. Building a cloud chamber similar to the one used in the film is neither difficult nor expensive, but it does require access to a shop. Perhaps the cloud chamber can be built in the school shop, or by the father of a student who has a small shop at home. You will need:

1. A small thermos bottle.
2. A small plastic dish, about two inches deep and about the same diameter as the thermos bottle.
3. A square of clear Plexiglass large enough to completely cover the plastic dish.
4. A copper tube, about half an inch in diameter and about five inches long.

5. A disk of copper, about 1/16 of an inch thick and about three inches in diameter. (It must fit inside the plastic dish.)
6. Some black paint.
7. Some blotting paper.
8. A source of a beam of light. A 35mm slide projector will work very well.
9. A source of radiation. (One numeral cut from an old luminous watch dial should work.)
10. Alcohol. (Plain rubbing alcohol will do.)
11. Dry ice.

onstruction:

See FIGURE TWELVE)

1. Solder the copper tube to the center of the copper disk. (This is the only step in the construction which cannot conveniently be done in the classroom by the students and teacher.)
2. Cut a hole in the center of the stopper of the thermos bottle just large enough so that the copper tube can be squeezed through it. This hole can be made by heating the copper tube in a gas flame and forcing it through the stopper.
3. Punch a second hole in the stopper. This hole need be no larger than a sixteenth of an inch in diameter.
4. Cut a hole in the center of the plastic dish. This hole should be just large enough for the copper tube to fit through. The hole can be cut with a small hand jigsaw after a starting hole is drilled with a hand drill. Or it can be made by heating the copper tube and forcing the hot tube through the plastic dish.
5. Paint the top surface of the copper disk black.
6. Cut a strip of blotter about half an inch wide and long enough so that it can be fitted inside the plastic dish and go all the way around its inside edge.

Operation:

1. Wrap the dry ice in a heavy cloth and crush it with a hammer.
2. Wearing heavy cloth or leather gloves, pack the thermos bottle with the crushed dry ice.
3. Pour alcohol into the thermos bottle, as much as it will hold.
4. Slide the copper tube through the hole in the plastic dish. The copper plate should be inside the dish now with its black side up.

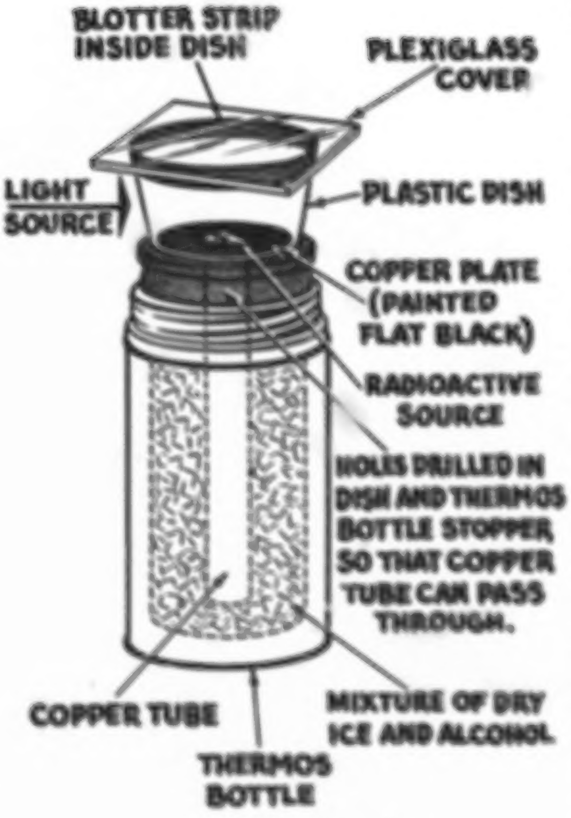

BLOTTER STRIP INSIDE DISH
PLEXIGLASS COVER
LIGHT SOURCE
PLASTIC DISH
COPPER PLATE (PAINTED FLAT BLACK)
RADIOACTIVE SOURCE
HOLES DRILLED IN DISH AND THERMOS BOTTLE STOPPER SO THAT COPPER TUBE CAN PASS THROUGH.
COPPER TUBE
MIXTURE OF DRY ICE AND ALCOHOL
THERMOS BOTTLE

FIGURE TWELVE

5. Slide the copper tube through the hole in the thermos bottle stopper. Force the stopper all the way up the tube so that it holds the plastic dish in place.
6. Force the copper tube all the way down into the thermos bottle so that the thermos bottle stopper fits in place. You may have to force the tube down into the dry ice by hammering on the copper plate. Or you can use a stick or screw driver to ream out a space in the ice for the tube.
7. Soak the strip of blotter in alcohol.
8. Fit the blotter inside the plastic dish around its upper edge. The alcohol should make it stick to the sides of the dish.
9. Place the bit of watch dial on the copper plate, face up.
10. Cover the plastic dish with the square of Plexiglass.
11. Shine the beam of light from the slide projector into the plastic dish from the side, so that the light passes under the strip of blotting paper.
12. Look down into the cloud chamber. Soon you should see the streaks.

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Evidence For Molecules and Atoms

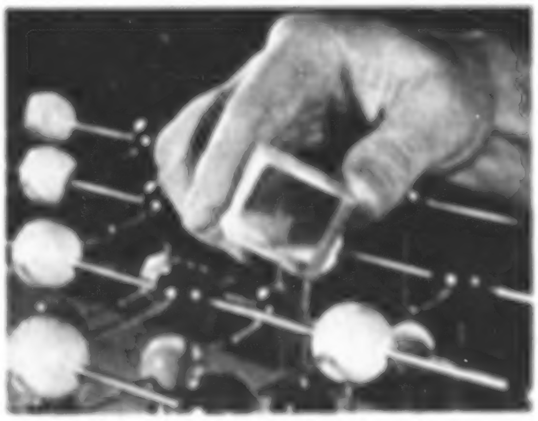
Film Summary

In a courtroom the defendant on trial is waiting for the jury's verdict. It is pointed out that circumstantial evidence can be used in a courtroom to prove that something happened, even though no one saw it happen. Circumstantial evidence is also used in science. A scientist is concerned with a great many things that he cannot see. Often he depends on circumstantial evidence to prove that unseen things do exist.

First piece of evidence to prove that such things as molecules and atoms really do exist: a piston that can slide up and down is enclosed in a small plastic box. Under the piston is a pile of BB's. When the BB's are agitated, they hit against the piston and lift it up. A continual bombardment by the small BB's holds the large piston up in the air. A weight placed on the piston pushes it down a little, but the BB's still hold it up. Now we look at a similar piston. This one has no BB's under it. Instead, air is blown into the space under the piston. The piston rises. Put a weight on it, and it goes down a little. The piston held up by air acts in much the same way as the piston held up by the bombardment of the BB's. Is it possible that the air is made up of tiny, invisible pellets, or particles, far too small to be seen, that bombard the piston and hold it up?

Second piece of evidence: a group of boys and girls shoot marbles at a blackboard eraser from all directions. The bombardment of the marbles pushes the eraser back and forth with a random motion. Now a small container is filled with smoke, and a light is projected into it. Through a microscope we can see bright particles of smoke dancing around with a random motion similar to the motion of the blackboard eraser. What is making the particles of smoke move? Is it possible that they are being pushed by still smaller particles of which the air is made up? Many pieces of circumstantial evidence added together have led us to believe that this is the case. The small unseen particles are called molecules.

Third piece of evidence: a fine, white powder is mixed with water. When we look at it through a microscope, the bits of white powder dance around in a random fashion, moving in very much the same way as the smoke particles and the blackboard eraser. This piece of evidence suggests that water is made up of molecules that are hitting against the particles of powder, making them move.



Fourth piece of evidence: how about solid materials? Are they made up of molecules, too? We look at a piece of crystal, then hit it against the table. The crystal is obviously hard. But a gentle tap with a razor blade splits the crystal cleanly in half, leaving two smooth edges. Now we look at an atomic model of a crystal. We see the regular arrangement of the molecules and atoms. We see how easy it is to cleave the model between rows of atoms, leaving two regular surfaces. If the crystal is not made up of small particles arranged in a regular order like this, why does it split so easily, leaving such smooth edges?

Fifth piece of evidence: a girl makes rock candy. She hangs a string in a solution of sugar and water, leaving it there for some 36 hours. When she comes back to look at it, crystals of sugar have formed on the string. Now, through a microscope we see crystals growing. They grow in a very regular way; the edges are always straight. Why do they grow in this regular way if they are not made up of smaller particles that are arranged in a geometric fashion?

Sixth piece of evidence: two electrodes are suspended in a solution. A crystalline metal structure is attached to one of the electrodes. When the wires to the battery are reversed, the metal disappears from the electrode it was on and appears on the other one. But we cannot see any material passing through the solution between the two electrodes. This piece of evidence suggests that the material passing between the electrodes passes in tiny particles far too small to be seen.

Seventh piece of evidence—three photographs: the first is a picture made by shooting X-rays through a piece of crystal. The picture shows a geometric structure. It is not a picture of atoms, but it does suggest a regular pattern of construction inside the crystal. Second photo: through an extremely powerful electron microscope, we see a photograph of an actual molecule. Third photo: this is taken through a special kind of microscope. The dots are images of individual atoms.

We see five clear liquids in identical containers. The liquids all look alike. When the first one is poured, nothing happens. The second one burns. The third puts the fire out, and the fourth etches a metal plate. The fifth one is not poured, because it is radioactive. It makes a radiation counter react. The five liquids look alike, but each acts very differently. There must be unseen differences in the arrangements of their atoms and molecules that makes each of them act in a very individual way.

Introduction to the Film

If you ask a group of children how many of them believe in atoms you will find that almost all of them will answer in the affirmative. If you ask them how many have *seen* an atom, or molecule, few if any will raise their hands. So, it is commonplace to believe in things that we have not seen. The reason is simple. The evidence for the existence of these things is circumstantial, but overwhelming.

There is a very important difference between the way circumstantial evidence is used in a court and the way we are using the term in connection with science. The circumstances on the basis of which a jury reaches a decision are events which occurred once and which cannot be readily repeated. On the other hand, in science, the strength of circumstantial evidence comes from the fact that a given set of circumstances has been duplicated over and over again in many different places and by many different people. There is no question about the validity of any point in science, the proof for which is based on circumstantial evidence, because ultimately we resort to experimentation and verification by repetition.

The evidence for molecules and atoms ranges all the way from commonplace observations to very sophisticated experiments requiring the most sensitive tools at the command of science. The film shows mostly the kind of demonstration which can be performed without very elaborate apparatus, but which, nevertheless, might be beyond the capacity of the teacher because of time required for preparation, or perhaps because of cost or danger. For this reason, it would pay to see the film more than once, because the importance of some of the demonstrations may be missed the first time.

Evidence for molecules and atoms comes from solids, liquids, and gases. Water in a glass, left in a room, eventually evaporates. The molecular explanation is that the molecules of the water left it to become molecules of gas.

One of the key experiments in the history of atomic physics is the observation of Brownian motion. Smoke particles, when viewed under a microscope, exhibit a random, chaotic motion which we attribute to a ceaseless bombardment by invisible molecules of air. The effect also occurs in liquids, and in the experiments below we describe how to do a simple experiment that will show Brownian motion in a liquid.

In solid objects the molecules are *not* as free to move around as they are in liquids or gases. Therefore, we cannot exhibit a Brownian motion for the molecules of a solid. The evidence for molecules and atoms in solids comes primarily from the fact that order exists in the way solids are put together. Observing a crystal grow, we see that it grows in straight lines. That is, the surfaces of the growing crystal are always flat. The geometric construction of crystals seems to be determined by the fundamental building blocks from which crystals are made. In other words, crystals grow with flat surfaces because their growth is the result of layers of atoms being added, one layer at a time. And these layers are geometric and flat.

There are some experiments presented in the film which it would be best *not* to try to reproduce in the classroom. For example, the *experiment with the five clear liquids is actually a rather dangerous one. Igniting acetone could be dangerous in the classroom or laboratory. The fumes from carbon tetrachloride are dangerous when you breathe them. The acid which falls on the copper plate in the picture could do serious damage if it landed on the hands of the experimenter or on his clothing.* And, of course, *radioactivity is dangerous, too,* but oddly enough, the extremely weak solution of radioactive material used for the demonstration in the film is probably *least* dangerous of all the liquids except for the water.

What the film is trying to do is to answer this question: what are the simple and compelling evidences existing all around us in our daily lives that indicate that there are such things as molecules and atoms?

Demonstration To Be Presented Before Showing The Film

Ask the students to raise their hands if they believe in atoms. Next, ask them to raise their hands if they have seen an atom or a molecule. Next, ask them to mention any word which comes to mind in association with the word "atom" or "atomic."

As a simple demonstration, take some perfume or cologne and wet a paper towel with it. Wave the paper towel back and forth and ask each student to raise his hand when he smells it. The students nearest you will raise their hands first and those farthest away will raise their hands last. Now ask the students what they think actually happened. How did the smell get from the towel to them? Was it something like a sound wave or a water wave traveling on the surface of water? Or were there actually little "somethings" that moved invisibly through the air from the towel to the individual? Ask them to keep this question in mind as they watch the film.

Another simple demonstration is to take some ink and put a drop into a glass full of water. Notice that the ink starts to move downward within the liquid, but that it also moves outward. Why? Gravity explains the downward motion, but why would any of the ink want to go horizontally?

After the film is over, go back to the glass and you will find that the ink has diffused throughout the whole glass—that is, you will no longer see a blob of ink in one place. The whole thing will look blue or whatever color the ink happens to be. Now you can ask the students to explain what happened and chances are they will give a molecular explanation.

Experiments and Projects

1. The Brownian motion of smoke particles can be easily observed if a little chamber such as the one used in the film is obtained from a scientific supply house. The microscope should be set at a magnification of about 50 times.

A procedure which is simpler and more direct, although a little harder to see, is to observe the Brownian motion of fairly large particles in liquid. Following are instructions for making lead carbonate particles. These particles happen to have a metallic gleam which makes them easy to observe as they move about in water.

NOTE: The chemicals called for in this and following experiments are not dangerous if handled with ordinary care. They should not, of course, be tasted or eaten. In general, these chemicals will be available at a drugstore or high school chemistry supply room. If the preparation of the chemicals is done in the classroom, the chemicals should be handled only by the teacher.

Add about one cubic centimeter of one per cent potassium carbonate solution (prepared by dissolving one gram of potassium carbonate in one hundred cubic centimeters of water) to 250 cubic centimeters of water in a large beaker. Then dilute one-half cubic centimer of a 1% lead acetate solution in 100 cubic centimeters of water. Mix the two dilute solutions together in a five hundred cubic centimeter beaker and stir. The mixed solution may be diluted indefinitely once the reaction has taken place. If a cloudy or milky suspension results from the mixture of the two solutions, then the concentrations used were too high, and the preparations should be repeated with the individual solutions diluted further. In order to see the Brownian motion properly, you will find that the best thing to do is to place the mixture against a dark background. Shine a bright light into the mixture from the side so that it does not hit the background. Look at the particles through a magnifying lens. Describe their motion.

2. Get used to looking at objects through a magnifier, preferably between 5- and 10-power magnification. Look at salt, sugar, sand, and make some observations about their structure. Do they look crystalline under a magnifier?

There are many substances which grow in crystalline form which can be obtained at the drugstore. As a simple example, epsom salts. To grow a large crystal requires some care. Detailed and interesting information about crystals and how to grow crystals can be found in *Crystals and Crystal Growing* by Alan Holden and Phyllis Singer.*

Here are instructions for growing a rock candy crystal: put 2 level tablespoons of granulated sugar in a small drinking glass and add 2 tablespoons of water. Cover the glass with a piece of waxed paper held on with a rubber band. Stand the glass in a saucepan of water and heat the saucepan on the stove. Move the glass occasionally until all the sugar is dissolved.

Now stand the glass in a thin layer of water at room temperature to cool its bottom surface. Add five or six granules of sugar, making sure that they sink through the surface of the sugar solution to the bottom of the glass. These granules will act as seeds for the crystal. Remove the glass from the water and set it aside in a quiet place. The crystals will grow slowly for several weeks. Except during the addition of the seeds, the glass should remain covered by the wax paper.

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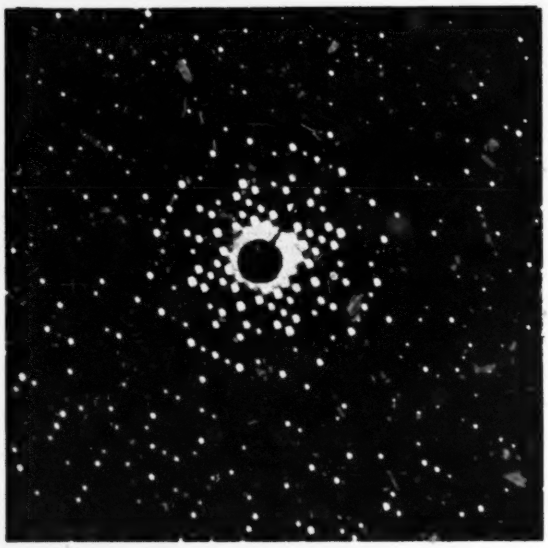
*Published in pocket-book form as part of the *Science Study Series* by Anchor Books, Doubleday & Co., Inc., Garden City, N.Y., 1960.

Salol, the crystal which was seen growing under a microscope in the film, is particularly easy to work with. If you heat a small amount of this material until it becomes liquid, you will see crystals form when it cools, provided you look at it through a microscope with a magnification of about 50 power.

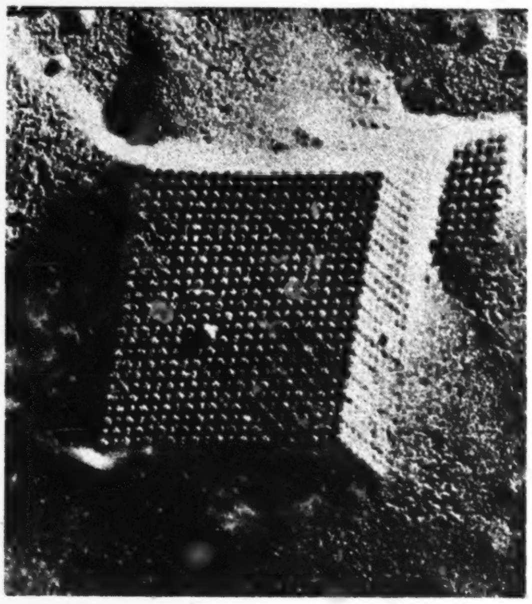
Excellent models of certain kinds of crystals can be made by using gumdrops to represent the atoms and toothpicks to represent the forces that bind them and that keep them at a constant distance from one another.

3. When a single drop of certain liquids is allowed to fall on a surface of water, it will spread itself out until it is one molecule thick. Make a solution of oleic acid in alcohol as follows: measure 5 cubic centimeters of oleic acid and 95 cubic centimeters of alcohol in a graduated cylinder and mix them in a clean bottle. Shake the mixture well. Then measure off 5 cubic centimeters of this solution and mix with 45 cubic centimeters of alcohol. Put water in a large, shallow tray, about two feet in diameter, to a depth of about half an inch. Cover the surface of the water with a very light dusting of some powder such as talcum powder, or chalk dust (just tap a blackboard eraser over the tray). The powder will make the spreading of the film visible. Now, using an eyedropper, drop one drop of the solution onto the surface of the water in the tray. The oleic acid will push outward, spreading over a large area. Repeating the experiment with the same dropper will produce a pattern of about the same size each time, showing that the layer is automatically thinning itself out, always to the same thickness. That thickness is the thickness of one molecule of oleic acid. The actual thickness can be computed if we know the volume of oleic acid in a given drop. This is a challenging problem for one of the brighter students.

4. It is not difficult to duplicate the lead-tree experiment shown in the film. You will need a fairly powerful battery (an automobile battery works well), some strips of lead, some wire, some lead acetate solution, some acetic acid, and a glass jar. Using two pieces of wire, attach the two strips of lead to the two posts of the battery. Place the two strips of metal in the glass jar without letting them touch each other. Now fill the jar with a saturated solution of lead acetate. Add a few drops of acetic acid. Wait and watch. The characteristic formation of the lead-tree should soon appear and grow on one of the strips of metal (or electrodes). After the lead-tree has formed, reverse the wires to the battery. What happens? It does seem that electricity and matter are connected in some way.

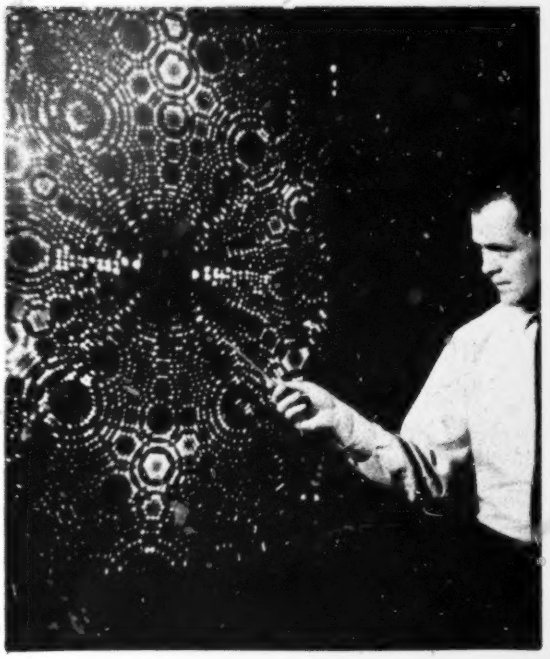


5. This is an X-ray diffraction photograph. A beam of X-rays is aimed at a crystal of the protein lysozyme. The atoms of this material diffract the X-rays off into certain directions. The apparent order of the resulting picture gives some notion, some concept of the order that must exist among the atoms of the material. Mathematical analysis based on such photographs tells us something about the approximate distances between atoms in a crystal. (Photograph courtesy of Robert B. Corey, California Institute of Technology.)



This photograph of molecules is made through an electron microscope. An electron microscope, as the name implies, uses beams of electrons rather than light. The magnification here is about 125,000 times. Such magnification is considerably higher than is possible with microscopes that use light. Each of the little ball-like objects, stacked neatly together, is actually an individual molecule of a virus protein material. These are big molecules. Each one is made up of a huge number of atoms. Molecules of many other substances are much smaller and may be made up of only a few atoms. (Photograph courtesy of Ralph W. G. Wyckoff, the University of Arizona.)

The photograph on page 76 is made with a Field Ion Microscope. The average magnification here is eight million times, and the individual white dots in the picture represent individual atoms. (Photograph courtesy of E. W. Mueller, Pennsylvania State University.)



6. Interesting transitions of material from solid to liquid or from liquid to gas are instructive from the atomic point of view. Low temperatures can be achieved by taking dry ice (CO_2), and crushing it and mixing it with almost any kind of alcohol. Pour some mercury into a rectangular mold such as a match box. Dip a tongue depressor, or any wooden stick that can serve as a handle, into the mercury. Then, if the alcohol and dry ice mixture is allowed to cover the mercury, it will eventually turn solid and make a mercury hammer with which one can actually hammer a nail.

It is possible to take a fire extinguisher which is filled with carbon dioxide gas and catch the gas on a towel which has been placed over the opening. As the CO_2 comes rushing out, it will form a layer of solid carbon dioxide on the towel. This is an interesting transition from gas to solid. The little pieces of solid carbon dioxide, if left on a table, will eventually disappear without leaving a wet spot. This shows that the molecules of CO_2 are capable of going directly from the solid to the gaseous state without going through the liquid phase. By the way, moth balls do the same thing.

7. Pour a few drops of water into a one-gallon can that has a screw-on cap. Heat the can over a gas flame. When the water

inside begins to boil, and steam is coming out the open top, remove the can from the flame and screw on the cap. Wait a few minutes. As the can cools, it will begin to collapse under the force of atmospheric pressure. What happens is this: when the can is heated, some of the water inside is transformed into water vapor. This water vapor fills the can. When the can is capped and allowed to cool, some of the water vapor turns back into water. Water takes up less space than water vapor, so much of the space inside the can is now relatively empty. The outside of the can is being continually bombarded by the molecules of the atmosphere. These molecules exert a force against the outside surfaces of the can. There are not enough molecules left inside the can to push against the inside surfaces with an equal force—so the can collapses. This is an indirect but rather dramatic proof of the existence of molecules.

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pp. 154-160

III. Energy - A. (continued)

Name and Description of Film	Other Grade Placements	Remarks
8. Water and What it Does	Gr. 6 - Gr. 3 - Gr. 7 -	No eval. yet No eval. yet No eval. yet
EBF, 1962; 11 min., color		
Some basic concepts about the nature and properties of water are illustrated. The dissolving property of water is demonstrated by adding sugar to it. Evaporation is illustrated by watching clothes drying outdoors and by seeing water vapor rise from a teakettle. Condensation and expansion of water is demonstrated. A balloon stretched over the neck of a flask expands as water is heated and vapor (or gas) is formed. A locomotive, driven by the force of expanding water vapor, shows the power of steam and some of its uses.		

* Good
** Excellent

III. Energy

L. Chemical energy

Name and Description of Film	Other Grade Placements	Remarks
1. Explaining Matter: Atoms and Molecules * EBF, 1958; 14 min. Presents the atom as the building block of matter and shows the interrelationships between atoms, molecules, elements, compounds, and mixtures. Indicates that the number of different substances which can be made from the more than one hundred types of atoms is infinite. Explains how atoms are combined to form molecules and how these molecules may exist separately or in combination with others, to form elements or compounds.	Gr. 9 - **	Diff. vocab.
2. Explaining Matter: Chemical Change ** EBF, 1960; 12 min., color Describes chemical change as part of everyday life, explaining that such ordinary things as fire, growing plants, and growing bodies depend on complex chemical changes. Uses animation, laboratory demonstrations, and molecular models to visualize difficult concepts, showing how the atoms from the molecules of two or more materials recombine with each other to form molecules of entirely different materials, how chemical changes can produce energy in the human body through the process of digestion, and how they make food in green plants through the process of photosynthesis.	Gr. 9 - **	

* Good
** Excellent

Energy - L. (continued)

Name and description of Film	Other Grade Placements	Remarks
3. Fire Science ** Churchill-Wexler, 1960; 15 min., color An introduction to the chemistry of combustion. Highlights historical uses of fire and the importance of fire in today's civilization. Uses animation to visualize the molecular action of a burning fuel whose carbon and hydrogen atoms combine with oxygen to form carbon dioxide and water, releasing energy in the form of heat and light. Experiments explain the concepts of fuel, oxidation, kindling temperature, and spontaneous combustion.	Gr. 5 - ** Gr. 9 - *	
4. The Fire Triangle * Film Assoc. of Calif., 1963; 13 min., color Fuel, heat, and air are the three elements that make up the "Fire Triangle." Before a fire can start, these three elements must be present. To control a fire, one (or more) of these elements must be removed. Firemen control fires by removing the fuel so there will be nothing to burn; by applying water to help reduce heat; or by smothering the fire with heavy chemicals to keep the oxygen in the air away. Understanding the science of fire helps firemen control fires.		
5. Fire: What Makes it Burn EBF, 1962; 11 min., color Simple laboratory experiments with matches, a candle, a piece of coal, dry wood, paint cans, and crushed brick demonstrate that fire needs fuel, heat, and oxygen to burn, and that different degrees of heat are required for combustibility of different materials. Fire is extinguished when fuel/heat/oxygen are removed. We see a campfire and a forest fire and learn that fire can be dangerous as well as useful. Safety is stressed.		No eval. yet

* Good
** Excellent

Energy - L. (continued)

Name and Description of Film	Other Grade Placements	Remarks
6. Introduction to Electricity * Coronet, 1948; 11 min., color Introduces the basic principles of electricity. Investigates, through the interests of two students, static and current electricity, showing how the natural repulsion of electrons makes electricity with chemicals and with magnetic lines of force.	Gr. 5 - ** Gr. 9 - *	For slower groups
7. The Nature of Burning ** McGraw-Hill, 1963: 16 min., color The ordinary candle is used as an example of burning. The film explains that the source of the heat and light is the combination (oxidation) of the vaporized fuel (hydrocarbon) with oxygen. It explains that the light comes from particles of carbon raised to incandescence and the heat from the oxidation of the fuel. Demonstrations show that the fuel must be raised to its kindling temperature, and that the combustion products are carbon dioxide and water.	Gr. 4 - **	
8. Oxygen * Coronet, 1947; 11 min. Through laboratory experiments, develops the characteristics, uses, and significance to man of oxygen and its compounds. Surveys the preparation, properties, and characteristics of this element, and explains electrolysis, oxidation, forms of oxygen, etc.	Gr. 9 - ** Gr. 12 - *	Needs prep. Early 12th

* Good
** Excellent

III. Energy

C. Mechanical energy and simple machines

Name and Description of Film	Other Grade Placements	Remarks
1. Energy and Work ** EBF, 1961; 11 min., color Uses simple experiments and visual experiences to explain the basic concept that energy is neither created nor destroyed, but simply changed from one form to another. Illustrates ways in which energy can be stored, ways in which potential energy can be changed into kinetic energy, and how kinetic energy can be changed into mechanical energy for the purpose of doing work.	Gr. 9 - **	
2. The Force of Gravity ** McGraw-Hill, 1961; 27 min., color Understanding of present day geophysical research and to increase man's understanding of the force of gravity.	Gr. 9 - *	Needs prep.
3. Friction, How it Helps and Hinders ** United World Films; ; 13½ min., color This film shows: How friction is affected by weight, pressure, lubrication, shape and surface of objects. How the control of friction affects our present day economy. How this force influences our daily lives.		

* Good
** Excellent

Energy - C. (continued)

Name and Description of Film	Other Grade Placements	Remarks
4. Forces ** EBF, 1961; 13 min., color Presents a visual explanation of the scientific concept of forces--what they are, what they can do, and how they are measured. A series of demonstrations show that forces can sometimes change the shape of an object, that they can speed up or slow down a moving object, and that a continually applied force can make an object move in a curved path. Illustrates the effects of electrical forces, magnetic forces, and the force of gravity.	Gr. 9 - **	
5. Gravity ** Coronet, 1950; 11 min., color Through a variety of everyday examples explains the force of gravity. Shows attraction in relation to mass and distance, and the effect of gravity on our solar system. Demonstrates and explains mutual attraction between all bodies.	Gr. 5 - ** Gr. 8 - ** Gr. 9 - **	Also listed IV-F
6. Gravity - How It Affects Us ** EBF, 1960; 14 min., black & white Illustrates gravity's importance by showing some of the things that gravity does; its action upon our daily activities, its effects on our earth, and how it would affect a human being on an imaginary trip through outer space. Includes sequences on the experiments of Galileo and Isaac Newton.	Gr. 2 - ** Gr. 3 - ** Gr. 9 - **	Also listed IV-F A little adv.

* Good
** Excellent

Energy and Work

Film Summary

We watch the progress of a boy who wakes up one morning feeling full of energy. Because he is full of energy, he feels like moving around and doing things. He mows the lawn, and that is work. But if he had gone canoeing, that would have been work, too. Because in science, the word "work" means using energy to make something move, or to make something stop moving.

The boy winds up the rubber-band motor of a model airplane. It takes energy to do the work of turning the propeller and winding up the rubber band. He hooks the propeller so that it cannot turn. The rubber band is still twisted when the boy returns that afternoon after school. He takes the airplane outside, lets the propeller spin, and the plane flies off. It takes energy to do the work.of making the airplane move through the air. Where is that energy coming from? It comes from the energy the boy used to turn the propeller and twist the rubber band. But he did that several hours ago. The energy had been stored in the twisted rubber band since then.

There are many ways to store energy. Two acrobats haul down on a pulley, lifting a heavy sandbag up into the air. Some of the energy it took to lift the sandbag up into the air is stored in the sandbag when the rope is locked off and the sandbag is left hanging. Energy that is stored is called potential energy. Later, the sandbag can be let fall so that it hits a teeterboard and sends one of the acrobats flying through the air. It takes energy to do that, and that energy came from energy that was stored in the hanging sandbag.

We are at a gas station. The stream of gasoline from the pump fills a red can. There is energy stored in gasoline. And this kind of potential energy is handy because it can be easily moved from one place to another.

A power lawn mower sits on a huge front lawn. The boy pours gasoline from the red can into the mower's gas tank. He starts the mower, climbs aboard, and drives off cutting a swath across the expanse of green grass. The potential energy stored in the gasoline is doing work now, the work of cutting the lawn.

A bowling ball smashes into the pins. The boy bowls another ball. Some of the energy it takes to bowl the ball is carried by the moving ball to the other end of the alley, where it does the work of knocking the pins down. Now we see a wrecking ball smashing against a building. There is energy in all moving objects. Energy in moving objects is called kinetic energy. And like all energy, it can do work. The moving wrecking ball does the work of knocking a wall down.

There is kinetic energy in moving water. Men have long put this energy to work. We see an old mill. The wheel is turned by the kinetic and potential energy of moving water. Now we see Hoover Dam. In the powerhouse of the dam the kinetic and potential energy of moving water does the work of turning huge generators to produce electric energy.

A small wrecking ball hangs from a chain. The boy pulls it back until he is backed up against a cement block wall. He holds the wrecking ball against his face and lets it go. The moving ball has kinetic energy. It hits against a brick wall and smashes it. Now the boy catches the moving wrecking ball and holds it against his face again. He lets it go. It swings back and almost hits him, but not quite. He does this several times. Why is he so confident that the ball will not come back and hit him in the nose? The boy holds the ball in front of his face once more. But this time, when he lets go, he gives it a push and steps out of the way. When the ball returns, it smashes into the wall the boy was standing against. It's a good thing he stepped out of the way.

Introduction to the Film

The concept of energy is probably the most important single concept in all of physical science. We can see examples of energy all around us. For example, we feel the heat of the sun on our shoulders as we lie on the beach. That's energy. The tide slowly rises and moves a huge body of water with it. That takes energy. We look at the clouds overhead and they're moving along rapidly. The very fact that they're moving means that they have energy, but before that it took energy to raise water up from the ocean to form the clouds.

In physics, we say that something has energy if it has the ability to do work. That means we must consider the concept of work. It takes work to push a lawn mower; it takes work to chop a tree; but even when we play, we often do work, because work in physics means that you use energy to exert a push or pull to make something move. When you row a boat, you may be enjoying it, but making the oars move is work from the physical point of view. You may be having the time of your life on a sailboat, but when you use energy to hoist the sail, you do work. Whenever energy is used to make something move, work is done.

When a boy pushes a lawn mower, the energy to do that work is supplied by the boy, but that energy had to come to the boy in some complicated way from the food he ate. If you use a power mower, the energy to do the work comes from the gasoline. An electric hedge clipper gets energy to do the work of trimming a hedge from a source of electric power. We see, therefore, that food, gasoline, and electricity all possess energy, because eventually we can get work out of them.

The film on uniform motion pointed out that if you can get rid of friction and other external forces, a moving body, such as a rocket, can continue moving with a uniform motion forever. It doesn't take any energy or work to keep it going. But if the rocket should hit some object in space, it is easy to imagine that the rocket could do the work of smashing the object it hits. It doesn't take energy to keep the rocket moving, but the rocket possesses energy just because it is moving. That kind of energy is called *kinetic energy*. All moving objects have kinetic energy.

When you stretch a spring you do work. If you connect the two ends of the stretched spring to fixed hooks you have stored energy, because when you release the spring later, it can do work. Energy that is stored is called *potential energy*. Such energy is *potentially available*. It takes a lot of energy to do the work of carrying a suitcase weighing fifty pounds all the way up to the top of a fifty-story skyscraper. It takes energy whether you climb up the stairs all the way, or whether you get into an elevator and let it take you up. Once the suitcase is up on the fiftieth floor it possesses potential energy. If you dropped it out of a window, its supply of potential energy would be converted to kinetic energy which, when it hit the ground, would do the work of smashing the suitcase and probably the concrete sidewalk it hit.

An important concept of physical science today is that energy is neither created nor destroyed, but simply changed from one form to another. You can change kinetic energy to potential energy; you can change chemical energy, the kind that gasoline has, into mechanical energy; you can change electrical energy into heat energy; you can change heat energy into mechanical energy, and so on. In fact, the greatest storehouse of energy discovered in modern times is right inside the atom, and this atomic energy can be converted into any other form of energy.

Demonstration To Be Presented Before Showing the Film

Take a heavy book or other heavy object and by climbing up on a ladder or on a desk, place it as high as possible; for example, on a high shelf, or on top of a venetian blind frame. Now assert that it took energy to do the work of lifting the object. Does the book have energy stored in it? Place a paper cup on the floor at the point where the book will fall. Push the book off the shelf. It falls and crushes the paper cup. Did it take energy to crush the cup? Where did the energy come from?

Experiments and Projects

1. In an open field, take a heavy rock and throw it up into the air as high as you can possibly make it go. Now consider the following questions: Did it take energy to do the work of getting the rock up in the air? Where did the energy come from? Did the rock, as it traveled through the air, ever have any kinetic energy? If it did, at what part of its flight did it have the most kinetic energy? (Just as it left your hand.) Did the rock ever have any potential energy? If so, when did it have the most potential energy? (At the top of its arc.) When the rock landed on the ground, was it going faster than when it left your hand? (No.)

2. Take a cardboard milk carton and fill it with water. Place the full carton on the edge of a desk. Now we ask, does the water possess kinetic energy? (No.) Does the water possess potential energy? (Yes.) With an ice pick, punch a hole near the bottom of the box so that water can spurt out and be caught in a pan below. Does the water now possess kinetic energy? (Yes.) Where does it possess the greatest amount of kinetic energy? (Just before it hits the pan.) Is there some part of the water that possesses practically no kinetic energy, but still possesses potential energy? (Yes. The water still in the carton.)

3. Take a large magnet in one hand, and a large nail in the other. Let the nail stick to the magnet. Now pull the nail free from the magnet, but do not move it so far away that it is no longer attracted by the magnet. Now answer the following questions: Does it take work to remove the nail from the magnet? When it has been removed, does the nail possess potential energy? When you release the nail, does it possess kinetic energy? When is the potential energy greatest and when is the kinetic energy greatest? (Potential energy is greatest when nail and magnet are farthest apart. Kinetic energy is greatest just before the nail hits the magnet.)

4. Take a tennis ball and throw it against a wall and catch it on the way back. Do this several times. Does it take energy to start the ball going? Does it take energy to keep the ball going once it's started? Does the ball possess kinetic energy? When the ball hits the wall and stops for a split second, does it possess kinetic energy? Does it possess potential energy then? Does the ball bounce back with the same speed it had before it hit the wall? Now throw the tennis ball into a pile of sand. When the ball hits the sand pile, it does not bounce back. Now try answering these questions: Does the ball have kinetic energy before it hits? Does the ball have kinetic energy after it hits the sand? What happened to the energy? (It was used to do the work of moving sand and generating heat.)

5. When you rub your hands together, they get hot. You are converting mechanical energy into heat energy. Can you think of ways in which heat can be converted back into mechanical energy? How about a steam engine? Can you invent a simple engine in which heat from the stove in your kitchen could be used to supply energy to do some mechanical work?

6. Make a chart listing different kinds of energy: electrical, mechanical, heat, light, sound, atomic, etc. Draw an arrow from electrical energy to mechanical energy and name the machine or device that can convert electrical energy into mechanical energy. (The answer is an electric motor.) Now draw an arrow from mechanical to electrical energy. Name the device that can convert mechanical energy into electrical energy. (In this case the device is called a generator or a dynamo.) Now take any other pair and see if you can name the device that can convert energy from the one kind to the other. A very simple one is the device that converts electrical energy into light. Can you tell how to convert light into electricity? Sometimes you may have to go through several devices to get from one form of energy to another. For example, how do you get from heat to electricity? There will be some devices whose names the student has not heard of. But there may be some science-minded students who already know about photoelectric cells, for example, which have the ability to give you an electric current when light shines on them.

7. *The Wrecking Ball:* using any kind of ball attached to a long string, repeat the experiment shown in the film. Attach the string to the ceiling or to a pipe as near the ceiling as possible, and tie the ball at the other end of the string. Now have a student back up against a wall and, keeping the string taut, bring the ball up to his face until it touches his nose. Then have him release the ball *without pushing it* and wait

for it to come back. At first the student may reach for the ball and catch it in front of his face if he is afraid it is going to hit him on the way back. After he tries it several times, he should achieve enough confidence in the law of the conservation of energy to know that the ball cannot have more energy when it comes back than it had to start with.

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Forces

Film Summary

We watch a tug of war, then two groups of children pushing a huge beach ball. We see that forces are pushes and pulls. We also see that, when forces are balanced on an object, the object remains motionless. But when the forces become unbalanced, the object moves.

Now we see a hammer thrower spinning the hammer around his body. The athlete is exerting a force, pulling the hammer towards him at all times, but the hammer moves in a curved path. A force can make an object move in a curved path. In an animated sequence, we see the movement of the moon around the earth. Is there a similar force exerted on the moon, making it move in a circle around the earth?

Forces can change the shape of an object. We see several examples of objects being changed in shape by pairs of forces. If the object is elastic, it returns to its original shape when the forces are removed. We see a spring balance. A weight is placed on it. The force of the weight stretches the spring. When the weight is removed, the spring returns to its former shape. When several weights of the same size are placed on the balance, one at a time, the spring seems to stretch the same amount each time one of the weights is added. You can try the same thing with rubber bands and coat hangers. As each additional coat hanger is hooked onto the elastic band, does it stretch the same amount?

If an object is not elastic, a pair of forces can permanently change its shape. We see several examples of this. Finally, a strong man bends an iron bar. The same strong man is powerful enough to develop a pair of forces that can tear a telephone book in half. The strong man is a big, heavy man, but a small girl is able to lift him and his weights, if she has the help of a machine — in this case a simple lever. We see that a machine makes it possible to change the direction of a force, or to change the size of a force. We see several other machines at work. All of them demonstrate in simple visual terms that a force is being multiplied or that the direction of a force is being changed.

An impact can transmit a force. A sledge hammer hits a wedge. The wedge, in turn, forces a large log to split. In the laboratory, two iron spheres are suspended so that they hang next to each other. When one sphere is pulled back and let fall, it hits the other, and a force is transmitted. We watch in slow motion to see how forces are transmitted back and forth between the swinging spheres. Now we look at a similar setup with two permanent magnets replacing the steel spheres. When one of the magnets is pulled back and let fall, a force is transmitted to the other magnet. The forces are transmitted back and forth from one magnet to another in a way similar to that in which forces were transmitted between the steel spheres. But the magnets never touch each other.

An electrostatic generator attracts balloons without touching them. Again, a force is acting between two objects that are not touching each other. Another force that acts between objects that are not touching each other is the force of gravity. We see the athlete swinging the hammer around his body again, and then we see an animated view of the moon circling the earth. The athlete exerts a force on the hammer through the wire which connects the hammer to the handle he holds in his hands. How does the earth exert a force on the moon? Could it be a force such as gravity, which acts even though the objects are not connected to each other in any way?

Introduction to the Film

This film is about forces: what they are, what they can do, and how they are measured. Forces are very important in physics, but you don't have to be a physicist to appreciate the role forces play in our daily lives. Everybody knows what a push or a pull is, so we can start by saying that a force is simply a push or a pull. You push on a car when it has run out of gas and you pull on the line when it has a fish hooked at the other end. All athletic activities and practically all other activities of our lives involve pushes and pulls. In fact, plants and animals are said to be alive because they can exert pushes and pulls. It takes a force to get us started in this life and from that moment on, as we reach for food or learn to walk, we depend upon forces.

There are two kinds of things that forces can do to objects. They can deform them or they can accelerate them, and the way we measure forces depends usually on one or the other of these things. Let's consider the first.

You can flatten a rubber ball by stepping on it. You can stretch a steel spring by pulling on both ends. In general, pairs of forces can be used to stretch, compress, twist or otherwise deform objects. This leads to one way of measuring forces. A spring balance, or scale, is nothing but a steel spring to which a scale has been attached. A force of one pound stretches the spring one inch; a force of two pounds stretches it two inches; a force of three pounds, three inches, etc. When the forces stretching the spring are removed, the spring returns to its former shape. A deformed object that returns to its original shape when the external forces are removed, is said to be *elastic*.

But some objects do not return to their original shape after you remove the forces that are deforming them. You can mold clay by applying forces with your hands, and it keeps the shape you give it. Even things that behave elastically like steel cannot be stretched too far or they will break. The forces which a pair of scissors applies to a piece of paper will cut it, and of course you cannot put the paper back together again.

The other thing that forces can do is to make objects speed up or slow down. That is what we mean by acceleration.

If you push a beach ball, it will move. Keep pushing on it and it will move faster and faster. But you can also slow things down by applying retarding forces to them. If someone else pushes the beach ball from the other side, it will slow down.

In summary, then, a continually applied force will make an object accelerate. If a force is applied to a moving object, it may make the object slow down. And, finally, a continually applied force can make an object move in a curved path without making it speed up or slow down. If you tie a string to a weight and twirl the weight around you in a circle, you will find that you are constantly exerting a force. You are continually pulling on the string, pulling in toward the center of the circle. This is the sort of force which the earth applies to the moon, that keeps the moon traveling at a nearly constant speed in an almost circular path around the earth.

There are many kinds of forces, but all forces fall into three basic groups. There are gravitational forces. There are electrical forces. And there are nuclear forces.

Gravitational force is so common that we are almost unaware of its existence. It is like the air we breathe; we simply take it for granted. Everybody knows that if you hold a book in the air and release it, the book will fall to the ground. What force acted on the book and made it accelerate? The force of gravity. Here is a force that seems to be able to act at a distance. There was nothing attached to the book, and nothing pushed against it to make it move.

Electrical forces are less obvious but just as common. You can run a comb through your hair and then pick up little bits of paper with it. The bits of paper are being moved by an electrical force. You can pick up a nail with a magnet. Magnetism is a very special kind of force that is related to electricity.

It is much harder to give simple examples of nuclear forces. But nuclear forces are tremendously important because they are so powerful. We all know what an atomic bomb can do. The forces it releases are nuclear forces.

Demonstration To Be Presented Before Showing the Film

Write the following on the blackboard: A FORCE is a PUSH or a PULL. FORCES can DEFORM objects. FORCES can ACCELERATE objects. Take a lump of modeling clay in your hands. Show that by pushing the clay and pulling on it (in other words, by exerting forces on the clay) you can deform it. Now loop several rubber bands together into a chain. Stretch the chain. Forces are deforming it. Let go. It springs back to shape. The rubber band chain reacts differently to forces than does the clay. That's because the rubber bands are more elastic than the clay. Objects that are elastic can be deformed by forces, but when the forces are removed, the elastic objects return to their original shape.

Now, ask the class how forces can accelerate an object—that is, make it move. Stretch the rubber band chain across a desk. Have two students, one on either side of the desk, hold the ends of the chain firmly. Hook a blackboard eraser against the rubber band chain. Pull back, then let go. The eraser sails through the air. What made it move? Was there a force acting on it? Where did that force come from?

Experiments and Projects

1. Try to think of all the different occasions on which you have had to exert a push or a pull, no matter how large or small, from the moment you got up in the morning to the moment you sat at your desk in school.

2. What are some objects that can be slightly deformed by the application of forces but which spring back to shape when the forces are removed? Name some objects which break easily under the application of forces. Name some objects whose shape you can change with forces in such a way that the objects keep their new shape when the forces are removed.

3. Make a rubber band chain by linking three rubber bands to one another. Hang them from a hook on the wall. Hang a wire coat hanger from the rubber band chain and record how far it stretches the chain by making a mark on a piece of paper on the wall. Hang a second coat hanger from the chain and record the new stretch. Do the same with a third and fourth coat hanger. Now measure the distances between the marks on the piece of paper. Did each coat hanger produce the same stretch? Now remove the coat hangers one at a time and see if the rubber band chain goes back to its former position. Does it? Is a rubber band really elastic? That is, does it return to its original shape when the forces that deformed it are removed? (Rubber bands behave only approximately the way springs do.)

4. Drive three flat-headed nails into a flat board. Drive them only a half inch into the board. Viewed from above, the three nails form an equal-sided triangle with each side about a foot and a half long. Now place a second flat board so that it rests on the heads of the nails. Have three students stand on the board, one over each nail. Does the weight of the students drive the nails into the wood?

Now, without the students and the top board, drive one of the nails in with a hammer. This illustrates that great forces can be exerted by impact. Was it the weight of the hammer that drove the nails into the wood? It seems unlikely, when the much larger weight of the students' bodies failed to budge the nails at all.

5. Try to crack a hard nut between your two fingers. You can't do it? But with a nutcracker you can crack it easily. A nutcracker enables you to exert large forces on the nut by applying relatively small forces to the handles of the nutcracker. Any device which can produce a large force from a small one is called a machine. Think of different ways in which large forces are produced by small ones in your daily experience. For example, it takes a very large force to pull a nail out of a board, but you can do it with a claw hammer. Can you explain what's going on? How can you lift your car by the application of a small force?

6. The force that makes objects fall to the earth is called the force of gravity. The gravitational attraction between the earth and the sun keeps the earth in orbit. Gravity acts at a distance. Another kind of force that acts at a distance is electrical force. Take a comb and run it through your hair and prove that you can pick up tiny bits of paper with it. Can you make the bits of paper move before you actually touch them? Construct a stirrup out of thread as shown in FIGURE ONE and slip a ruler into it. Now the ruler is free to rotate horizontally. Stop the ruler turning. Run a comb through your hair several times, then see if you can attract the ruler by bringing the comb close to it. Try rubbing such objects as plastic coat hangers or milk bottles with a wool or silk cloth. Can you attract the ruler with them? Can you find a way to repel the ruler?

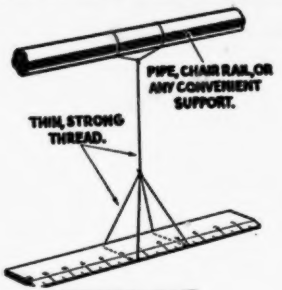

FIGURE ONE

7. Another kind of force that acts at a distance is magnetism. A powerful permanent magnet can pick up small nails without touching them. Bring the magnet close to the nails and the magnetic force will make them leap up to the magnet. Can a magnetic force act through a piece of cardboard? Or wood? Or aluminum foil? Try it and see.

8. This experiment requires two cylindrical magnets. Can you make the magnets repel one another? If you put one of them on an inclined plane, can you make it roll up the inclined plane by repelling it with the other? Hold one magnet at the bottom of the inclined plane. Hold the other at the top of the inclined plane, then let it roll down. As it approaches the bottom magnet, the rolling magnet feels a stronger and stronger repulsive force. It will roll down and get very close to the bottom magnet, then suddenly find itself repelled back upwards. When you toss a ball against a wall it bounces back. When you allow the one magnet to roll against the other, *it* bounces back. But with the magnets, nothing touched.

9. When you lift a suitcase, the suitcase seems to pull down on you. When you stub your toe by kicking a rock, it feels as if the rock had pushed back at you. In fact, whenever a force acts on an object, the object is capable of exerting an equal and opposite force. Hook two spring balances to one another. These can be the kind of balances that a fisherman uses to weigh his catch. Hold one balance in each hand. Pull on one of the balances until it reads one pound. Look at the other balance. What does it read? Continue pulling on the balance until it reads two pounds. What does the other balance read now? And why? Is this an example of equal and opposite forces? Explain.

10. Inflate a balloon and suddenly release it. What does the balloon do as the air rushes out? Did the balloon speed up? Was there a force acting on it? If there was, what produced that force? (See EBFilm ROCKETS: HOW THEY WORK.)

11. Suppose that you are in an ice boat on a calm day. Can you think of some ways of making the boat move? Suppose there were a pile of bricks in the ice boat. Could you make the boat move to the north by throwing a brick to the south? Does this give you any hint about how a rocket engine works?

12. Two cars collide accidentally on the road. One is large and heavy; the other, small and light. Which one do you think felt the greater force? (They both felt the same force. Forces always come in equal and opposite pairs.)

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Energy - C. (continued)

Name and Description of Film	Other Grade Placements	Remarks
7. Making Things Move EBF, 1962; 11 min., color The many kinds of forces which make things move are demonstrated by the movements of a windmill, sewing machine, bull-dozer, and rolling drum. A farm boy wonders what makes the baler, the barn elevator, the hole digger, the cart, and the truck move. He is lifted up into the truck, thrown back against the seat when it starts, and thrust forward when it stops. We see the effects of inertia, gravity, and friction--forces which keep things from moving and make them more difficult to move.	 Gr. 3 -	No eval. yet No eval. yet
8. Making Work Easier EBF, 1963; 11 min., color Watching men at work on a housing project, a young boy discovers that many objects in everyday use are simple machines which help to make work easier. The bricklayer rolling his wheelbarrow up the ramp is using an inclined plane; the carpenter turning a screw into the wall is using a spiral inclined plane; the workman chopping a log with his axe is using a wedge, as is his helper, who is hammering a nail into a board. A large board being used to move sewer pipe is a lever. The boy discovers that a pop bottle opener is a lever, also. A pulley is used to pull a bucket of cement up to the scaffolding. Complicated machines (steamshovels, tractors) are shown to be combinations of simple machines.		No eval. yet

* Good
** Excellent

Energy - C. (continued)

Name and Description of Film	Other Grade Placements	Remarks
9. Man in Flight ** Walt Disney, 1958; 33 min., color Depicts the early significant experiments of the ancient Chinese, Leonardo de Vinci, and of the aeronautical pioneers of France, England, and the United States. Shows in animation the successful efforts of the Wright Brothers and the exploits of those who followed. Stresses the impact of World War I on the rapid progress in aviation, concluding with live action sequences on the latest planes of the jet age.	Gr. 11 - **	
10. Moving Things on Land ** Churchill-Wexler, 1959; 11 min., color Jim and Bobby try to move a heavy box of comic books to Bobby's house. When they try to drag it, the uses and short-comings of friction are clearly demonstrated. The boys solve their problem and overcome friction by the use of sled runners and powdered soap to smooth the road, rollers, wooden wheels, metal wheels and roller bearing wheels.	Gr. 9 - **	
11. Simple Machines * EBF, 1941; 11 min., black & white Explains and demonstrates six basic machines and reveals how all machines, however, complicated, are merely combinations of these. Describes basic aspects of the inclined plane, the wedge, the screw, the lever, the windlass, and the pulley. Through natural photography and animated drawings, demonstrates the application of these devices to complex machines and explains the mechanical principles involved.	Gr. 11 - *	

* Good
** Excellent

Energy - C. (continued)

Name and Description of Film	Other Grade Placements	Remarks
12. Simple Machines: the Inclined Plane Family ** EBF, 1960; 11 min. Explains the operation of the inclined plane by following a young boy who discovers, through a series of simple experiments, how an inclined plane can make work easier. Explains the concept of work through the use of animated drawings. Also describes other machines of the inclined plane family--the wedge and the screw.	Gr. 9 - *	
13. Simple Machines: Inclined Planes ** Coronet, 1954; 6 min., black & white Shows how an inclined plane or slope facilitates the moving of heavy objects. Demonstrates the everyday use of the inclined plane and explains that such simple machines as screws and wedges are used when it is desirable to trade distance for force.	Gr. 2 - ** Gr. 9 - ** Gr. 11 -	No eval. yet
14. Simple Machines: Levers ** Coronet, 1954; 6 min. Describes combinations of levers which are found in complex machines, playground equipment, and many household tools. Models of first, second, and third class levers are shown and explained as is the fact that power may be increased when distance is traded for force.	Gr. 9 - **	

* Good
** Excellent

Energy - C. (continued)

Name and Description of Film	Other Grade Placements	Remarks
15. Simple Machines: Pulleys ** Coronet, 1954; 6 min. Shows how pulleys make possible the lifting of heavy loads with a minimum of effort. Explains that movable pulleys multiply force and fixed pulleys change the direction of a force.	Gr. 9 - **	
16. Simple Machines: Wheels and Axles ** Coronet, 1954; 6 min. The functions of rolling wheels and working wheels are compared and described on a bicycle and automobile. The forces exerted by a bicycle chain, rear axle, and rear wheel are shown with a spring balance. Explains the mechanical advantages of combining these forces with bicycle pedals and sprocket wheels and how pedals, sprockets and wheels multiply force in a rider's legs five times. A second example of belts and gears also illustrates the trading of force for distance.	Gr. 9 - *	
17. What is Uniform Motion? ** EBF, 1961; 13 min., color The two essentials of uniform motion are illustrated. The cause of friction is demonstrated. A frictionless air puck is made and used. The path of projectiles is examined to show that they are not illustrations of uniform motion.	Gr. 9 - **	

* Good
** Excellent

SCIENCE MOTION PICTURE FILMS - Grade Six
(Addendum

III. Energy

C. Mechanical energy and simple machines

Name and Description of Film	Other Grade Placements	Remarks
Simple Machines - Lever Family EBF, 1963; 14 min., color Uses demonstrations and animated diagrams to explain the operating principles of the basic machines in the lever family. Shows how the lever, pulley, wheel and axle are related to each other, and how each makes work easier.	Gr. 2 -	No eval. yet No eval. yet

* Good
** Excellent
4-15-66

What Is Uniform Motion?

Film Summary

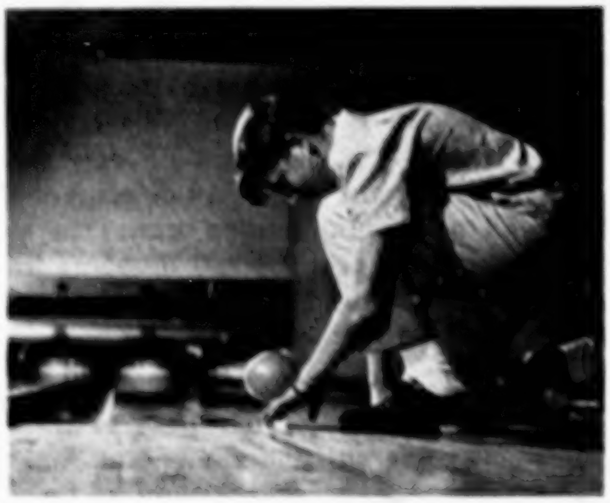
The film opens with a close-up of a jet plane, traveling high above the earth's surface. The jet is traveling with a uniform motion. That means two things: one, that the jet is traveling in a straight line; and two, that the speed of the jet is not changing. Now, we see a sports car traveling along a straight stretch of highway. Is the car traveling with a uniform motion? The car is traveling in a straight line and the speedometer indicates that it is traveling at a relatively constant speed. That means that the car is traveling with a uniform motion. Objects that travel with uniform motion travel equal distances in equal times. We can prove that.

A bag of chalk is attached to one of the wheels of the sports car. Each time the wheel turns once, the chalk bag leaves a mark on the pavement. When we measure between the chalk marks, we find they are equal distances apart. So, each time the wheel turns around once, the car travels the same distance forward.

It is twilight. A small light has been attached to one wheel of the sports car, replacing the bag of chalk dust. The sports car is moving with a uniform motion. Every time the light hits its low point, it means that the wheel has turned around once. We can tell by the rhythm that each complete turn of the wheel seems to be taking the same amount of time. We have already seen that each turn of the wheel measures off the same distance. So the car traveling with a uniform motion *is* traveling equal distances in equal times.

An easy way to prove this for yourself is to watch the dashed lines on the highway go by. They are painted on the highway equal distances apart. When the car is traveling with a uniform motion, the lines go by with a regular rhythm.

A boy on roller skates demonstrates that it takes a force to start an object moving, and it also takes a force to slow a moving object down. In many cases, the force that slows down a moving object is friction. In close-up photography, we see that friction is created when the uneven parts of rough surfaces hit against each other as they move past one another. Even surfaces such as polished metal, which appear to be smooth, really have rough places which can be seen under a microscope, and which can cause friction.



Now we take a close-up look at a smooth piece of plastic with a small hole cut through it. A balloon is fitted over the hole so that air from the balloon flows in a tiny jet through the hole. When the plastic disk is placed on a smooth surface, it rests on a thin layer of this air. The air acts as a kind of lubrication. There is very little friction between the plastic disk and the smooth surface of the bowling alley when the disk is given a push and sent down the alley. We see that an object moving with very little friction to affect it moves in a straight line and at an almost constant speed. In other words, it moves with a relatively uniform motion.

Now we go to a county fair. A "human cannon ball" climbs into his cannon and is fired. We see that he does not travel with a uniform motion. First of all, he is slowed down by friction with air. And he does not travel in a straight line, either. That is because the force of gravity is continually pulling him down towards the earth.

Now we look at a rocket traveling in outer space. The motor is shut off, but the rocket continues moving ahead with a uniform motion. In outer space, there is very little atmosphere to rub against the rocket and cause friction that would slow it down. And out in space the force of gravity is too weak to cause the rocket to change its direction. So the rocket continues moving ahead with a uniform motion, the natural way for an object to move when there is no force acting upon it to slow it down or cause it to change direction.

Introduction to the Film

Motion is all around us, and the observation of how things move is an important aspect of scientific study. Uniform motion is the simplest and most basic kind of motion there is. It is the natural way for an object to move if there are no external forces acting on the object. An object moving with a uniform motion moves in a straight line and covers equal distances in equal times. That is, it moves in a straight line with a constant speed.

For centuries men thought that it required a continually applied push to keep something going with uniform motion. And, at first glance, it certainly looks that way. Automobiles, airplanes, and submarines have engines that must supply a continual push to keep them moving. Sailboats require the wind to push them. When the wind dies down, they stop moving. If you slide a coin along a table, it eventually comes to rest. It does not seem to be true that a body once moving has a natural tendency to keep moving in a straight line with uniform speed. But Galileo pointed out that what stops the coin is a force called friction, and, if you could diminish friction or remove it completely, then the moving body would of its own accord continue to move in a straight line at a constant speed.

Today it is possible to reduce friction by several means, and experiment does seem to bear out the idea that, if you could remove friction completely, a moving body would continue to move with a uniform motion without requiring any additional force to push it.

If you point a gun up at a forty-five degree angle and shoot it, the bullet eventually comes down somewhere, so it couldn't have traveled in a straight line. It did not travel in a straight line because friction was acting on it, and also because the force of gravity pulled it back down to the earth. If you could remove both friction and the pull of gravity, the bullet ought to keep going in a straight line. We now know that, if you can fire a rocket vertically off the earth at a speed of about 7 miles per second, it will never return to earth. Where will it go? That depends on how close it comes to the gravitational field of some other body—a planet, for example. But for long stretches, the rocket will move in an area of space where almost no friction acts on it and where there is almost no gravitational pull at all. So the rocket will move with a uniform motion and will require no more push from its engine to keep it moving forward. The ideal envisioned by Galileo is something which can be realized rather accurately today.

In the laboratory, if you can minimize friction, you can do quite a few experiments to show that Galileo was right. In order to understand what uniform motion means, it is good to illustrate what non-uniform motion means. A body moves non-uniformly if it picks up speed or loses speed or if it changes its direction. In a car you have to step on the gas in order to pick up speed; you have to step on the brakes in order to slow down. You have to pull towards the center in order to keep anything going in a circular path, as in the case of the hammer thrower whirling the hammer around his body. In other words, non-uniform motion always involves forces.

Max Born, in his book entitled *The Restless Universe,* says he thinks it is strange that we have a word for something that doesn't exist, namely *rest.* Nothing is at rest. Everything is in motion. If you think the book that is lying on your desk is at rest, you simply have to remember the earth rotating on its axis to realize that the book shares this motion. Or, when you realize that the book is made up of atoms, you know that at the atomic level, the book is not at rest either. So motion is something that's around us; our daily lives depend upon it; and science as we know it today got its start when men like Galileo and Newton decided that the way to understand motion was to do experiments and take some measurements and reach some conclusions. The logical way to begin studying motion is to consider the simplest form of motion. That's why we start with uniform motion.

Demonstration To Be Presented Before Showing the Film

Slide a blackboard eraser across the floor. Ask the class to watch carefully how it moves. Do it several times, then ask: Does the eraser move in a straight line? (If the floor is level and the eraser hits nothing, it will move in a more or less straight line.) Does the eraser move at a constant speed? (It will move at a more or less constant speed until it slows and stops.) What makes it slow down and stop? (Friction.) What would happen if there were no friction and I started the eraser moving across the floor?

Experiments And Projects

1. Have someone give you a push when you are roller skating on a level sidewalk or paved playground. How far can you go without getting any more pushes and without moving your legs? What actually brings you to a stop? You may run into a tree, or you may have to stop yourself because you are approaching an intersection, or you may just slowly lose speed until finally you stop. In any case, answer this question: was there a force acting on you that eventually brought you to a stop?

2. One way to study friction is to make a chain of about four rubber bands; get an oblong block of wood and screw a hook into one end, and connect the rubber bands to the hook. Place the block of wood on a table-top, resting on one of its smaller sides. Note the position of the block on the table. Stretch the rubber band chain slowly until the block begins to move. Record the position of the end of the rubber band chain when the block first began to move. Repeat this several times to see if it always takes about the same amount of stretch to get the block started moving. Now turn the block so that it rests on one of its larger sides and repeat the experiment. Does it take more or less stretch to get it started? What do you conclude about the force of friction? Was it the same in both cases? Was the force of friction greater between the large surface of the wooden block and the table than it was between the small surface and the table? (No, the force is about the same.)

3. One way to reduce friction between an ordinary wood screw and the wood it enters is to put some soap on the screw. Do an experiment by first driving a screw home, turning it with a screw driver when the screw has no soap on it. Next, repeat the experiment with an identical screw that has been thoroughly soaped. Can you notice the difference in the force required to turn the screw?

4. It is not hard to build a "frictionless puck" of the type used in the film. You need a circle of smooth plastic about five inches in diameter and a half-inch thick, a balloon, and a cork. (See FIGURE TWO, p. 28.) Drill a hole in the center of the plastic disk large enough for the cork to fit in snugly. Do not drill this hole all the way through the plastic. Drill it only far enough so that the cork fits into it securely. Now drill the hole the rest of the way through the plastic disk, this time using a much smaller drill, one that makes a hole no bigger than one-sixteenth of an inch in diameter. Now drill a similar small hole through the length of the cork. And that is all there is to it. Fit the balloon over the cork. Blow up the balloon by blowing through the hole in the cork. Now, letting as little air escape as possible, fit the cork into the hole in the plastic disk. Now place the plastic disk on a smooth surface—a level, polished table will do—and give it a gentle push. If the bottom of the disk and the table-top are smooth enough, the little "frictionless puck" will keep moving until a force (a push from another direction, perhaps) stops it, or until it slides off the table or runs out of air. If you have a smooth gymnasium floor, the puck may go all the way across with only a gentle push to start it moving. Air, escaping from the balloon, forms a thin cushion on which the disk rests. The disk actually does not touch the surface on which it rests, (the table-top or the floor). And so, there is practically no friction act-

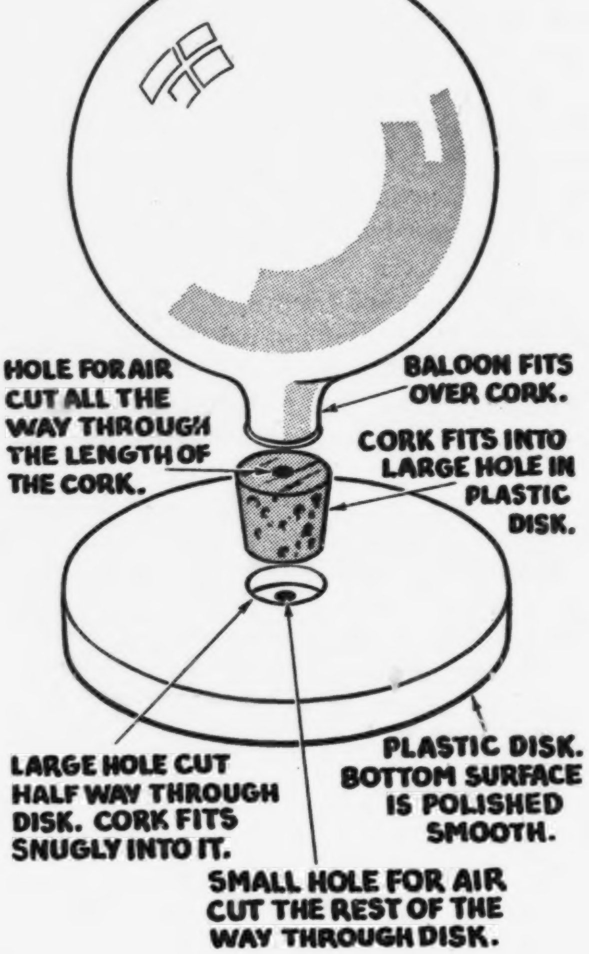

HOLE FOR AIR CUT ALL THE WAY THROUGH THE LENGTH OF THE CORK.
BALOON FITS OVER CORK.
CORK FITS INTO LARGE HOLE IN PLASTIC DISK.
LARGE HOLE CUT HALF WAY THROUGH DISK. CORK FITS SNUGLY INTO IT.
PLASTIC DISK. BOTTOM SURFACE IS POLISHED SMOOTH.
SMALL HOLE FOR AIR CUT THE REST OF THE WAY THROUGH DISK.

FIGURE TWO

ing on the "frictionless puck." Observe the motion of the "frictionless puck." Does it move with a uniform motion? Does it seem to travel equal distances in equal times?

5. Throw a baseball up in the air at a forty-five degree angle. Throw it as hard as you can. Does the baseball travel with a uniform motion? Let someone else throw the baseball while you observe the path of its flight from the side. Why doesn't the baseball travel with a uniform motion? Are there forces acting on it? What are those forces?

6. Make a chain of several rubber bands. Hook one end of the chain to the frictionless puck. Place the puck with the balloon blown up on a smooth surface. Hold a pencil down hard against the center of this smooth surface and hook the other end of the rubber band chain around the pencil. Give the puck a push. It will travel in a circle around the pencil. Is there a force acting on the puck? There must be because the rubber bands of the rubber band chain are stretched. A force is stretching them. Is it a force that is continually pulling the puck towards the center of the circle?

7. The next time you are in a car, ask the driver to drive at a steady speed, say thirty miles an hour. Then, using a wrist watch with a second hand, measure how much time it takes for the mileage gauge to register one additional mile. At thirty miles an hour it should take two minutes. Now, sit in the back seat. Ask the driver to travel at another steady speed, but ask him not to tell you what it is and don't look at the speedometer yourself. Ask the driver to keep an eye on the mileage gauge and say "Go" when a mile starts and "Stop" when it's past. Measure the time that passes between the "Go" and the "Stop." With this information, can you figure out how fast the car was traveling? For example, if the car took one minute to travel one mile, how far would it go in one hour? How fast would it be going?

8. The next time you drive down a road that has a line of telephone poles running along parallel to it, watch the poles go by. If the car is traveling with a steady speed, the poles may go by with a regular rhythm. If the poles do go by with a regular rhythm, does that mean that they are spaced in the ground equal distances apart? If you know how far apart they are spaced and if you have a watch, can you find out how fast the car is going?

9. Fill a balloon with air and release it, allowing the air to come out. Does the balloon move with a uniform motion? Does it move in a straight line? Does it move at a constant speed? Does it move in a curved path? Are there forces acting on the balloon? Do you think the balloon would have moved in the same way in interplanetary space? Or do you think the balloon has to have air to "push against"?

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III. Energy

F. Sound

Name and Description of Film	Other Grade Placements	Remarks
1. Learning About Sound * EBF, 1958; 8 min., b/w Develops the concept of sound and discusses its generation and transmission. Shows how the vibration of a string produces sound. Uses animation to depict air vibration. Illustrates the vibration of a drum head by using iron filings and the concept of vibrating air columns in the example of a willow whistle. Portrays sound graphically through the use of an oscilloscope. Demonstrates the transmission of sound through air, water, and metal and ends with a review of concepts and questions.	Gr. 2 - ** Gr. 9 - *	
2. The Nature of Sound ** Coronet, 1947; 11 min. Through everyday examples, explains the nature of sound. Studies the principles of sound's vibration, its characteristics, and transmission; and pictures sound on an oscilloscope.	Gr. 9 - ** Gr. 11 - *	
3. Sound and How it Travels EBF, 1963; 11 min., color Young vacationers learn what causes sound, why we are able to hear it and what determines its pitch. They hear the many sounds at the beach--a seagull's cry, an oyster boat's horn, the lapping of waves against the pier, the murmur within a seashell. A freighter blows its whistle, yet it cannot be heard until waves of sound vibrations travel to their ears. They discover that sounds travel underwater, through wood, and along a guitar string--its pitch varying as the string is lengthened and shortened. They learn that like a drum top, eardrums vibrate to sounds and the funnel shape of the outer ear helps to gather sounds from the world around them.	Gr. 6 - Gr. 2 -	No eval. yet No eval. yet

* Good
** Excellent

III. Energy - F. (continued)

Name and Description of Film	Other Grade Placements	Remarks
4. Vibrations ** EBF, 1961; 13 min., color Explains the causes and effects of vibrations and demonstrates the basic concepts necessary for the understanding of vibrations. Presents examples which illustrate that sounds are the results of vibrations, that rapid vibrations can be heard, and that objects which vibrate slowly cannot be heard.	Gr. 9 - **	

* Good
** Excellent

Additions to
Page 16

SCIENCE MOTION PICTURE FILMS - Grade Six
(Addendum)

III. Energy

F. Sound

Name and Description of Film	Other Grade Placements	Remarks
Discovering Where Sounds Travel ** Academy Films, 1964; 11 min., color Provides experiences in observing basic facts about the transmission of sound in air, water, and metal. Demonstrates that sound cannot travel in a vacuum. Shows how sound travels readily through water. Depicts that sound travels fifteen times faster through metal than through air. Stresses that sound and light travel through air at different speeds.	Gr. 9 - **	
Sounds and How They Travel Academy Films, 1965; 11 min., color Presents the mechanics involved in the transmission, reflection, and absorption of sound. Shows the transmission of sound through various materials such as water, metal and wood. Describes the reflection of sound waves and the formation of echoes. Explains the absorption of sound waves and the control of echoes. Shows how echoes can be useful.	Gr. 9 -	No eval. yet No eval. yet
Science of Musical Sounds * A C D, 1964; 11 min., color Provides an introduction to the basic principles of sound production. Uses three types of musical instruments--harp, flute, and xylophone--to illustrate the principles. Defines frequency, vibrations, tuning, pitch and overtones. Shows how an oscilloscope is used to draw electronic pictures of sound vibrations.	Gr. 9 -	No eval. yet

* Good
** Excellent
4-15-66

Vibrations

Film Summary

We see several different objects vibrating—some common, some unusual. Whenever an action is repeated over and over again with a more or less regular rhythm, then something is vibrating. Now we see several objects making noise. Sound is the result of objects vibrating. We look very closely at a tuning fork. The arms vibrate back and forth, and we hear sound. An animated diagram shows how the vibrating arms of the tuning fork strike against surrounding air particles. These air particles, in turn, strike against particles of air farther away. Finally, when the movement in the air reaches our ears, we hear sound.

A doorbell is suspended inside a jar from which air can be pumped. We hear the bell ringing through a microphone which is also in the jar. When the air is pumped out of the jar, we no longer hear the sound. Put the air back in, and we hear the bell again.

A girl swings on a swing. The movement of the swing back and forth is a vibration, but we cannot hear it. We cannot hear it because it is vibrating too slowly. Now we look very closly at a vibrating string. This vibration can be heard because it is much faster. Blowing into a dog whistle produces a vibration that is too fast to be heard by the human ear, but a dog can hear it.

We see one girl swinging on a swing with long ropes, and another on a swing with short ropes. The two swings vibrate at different speeds or frequencies. Every object that vibrates has a natural frequency of vibration.

Two tuning forks are set close to each other. When one of the forks is struck, the other one sounds, too. An animated diagram explains why one tuning fork can start another tuning fork vibrating, if they both have the same natural frequency of vibration.

We look closely at the strings of a guitar. A small piece of tissue paper is hooked over each string. A tuning fork is struck and placed against the guitar. The tissue paper jumps off one string only. Another tuning fork is struck and placed against the guitar. This fork makes the tissue paper jump off another string. The two tuning forks have the same natural frequencies of vibration as the two strings. When two objects have the same frequency of vibration, we say they are in tune with each other.

To start a vibration you have to use force. We watch a jazz combo playing. In order to make their instruments vibrate to produce music, the musicians have to use force. The drummer has to hit the drum, the trumpet player has to blow into his horn.

We see that it takes a force to start the swing vibrating. Here, stop-motion photography helps us to visualize the concept that two things are needed to make a vibration. One is a force that pulls the vibrating object toward a center position. The other is the natural tendency for a moving object to keep moving.

It is easy to start a ping-pong ball (hanging from a string) vibrating by blowing on it. If the blowing comes in spurts that are in rhythm with its natural frequency of vibration, the ping-pong ball on the string swings over a wider and wider arc. Now we see a bridge vibrating. Gusts of wind have started the bridge vibrating at its natural frequency. It vibrates over a wider and wider arc, until, finally, it falls.

Introduction to the Film

Why do we study vibrations? Fifty years ago the answer to this question would have been that the subject of sound is one of the most important subdivisions of physics and that vibrating bodies are essential in the production of sound.

Today the emphasis is different. Although we are still very much concerned with the vibrations that give rise to sound waves, today we know that there are other kinds of vibrations that can give rise to other kinds of waves. For example, electrical vibrations can produce radio and radar waves. And most important of all, light is a wave that has its origin in vibrating parts of an atom. We study vibrations today because you cannot get very far at all in the study of atoms without first knowing about vibrations and waves.

The basic requirements needed to make an object vibrate can be observed by watching a child on a playground swing. The motion of the child swinging back and forth is a simple vibration. What forces are required to make this vibration? Imagine the child seated quietly on the swing which hangs without movement at its center posi-

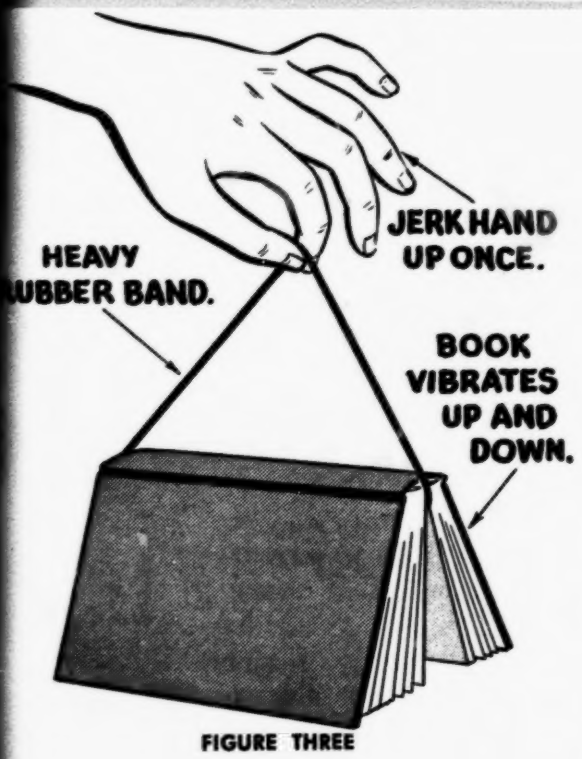

FIGURE THREE

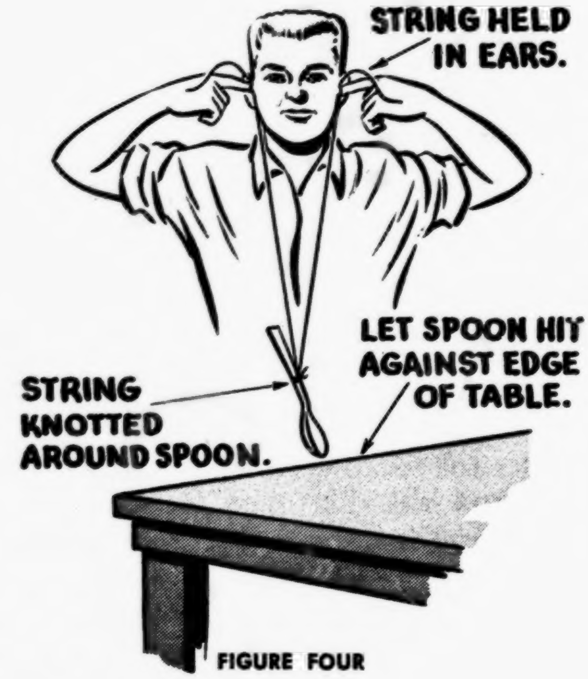

FIGURE FOUR

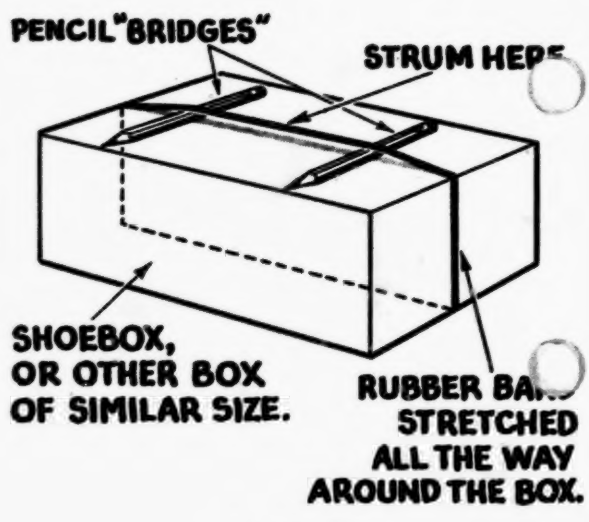

FIGURE FIVE

tion. If you pull the child back to get him started, you have to exert a force to do it. Now, when you let the swing go, another force pulls it back to the center position. That force is called a *restoring force*. Of course, the swing does not stop at its center position. Why not? Because inertia, the tendency for a moving object to keep moving, keeps it going. By the time the swing reaches the high point at the far side of the arc, the restoring force is pulling it back to the center again, this time in the other direction. Once again, inertia makes it move past center, the restoring force pulls it back again, and so on. And so, you have a vibration.

To start a vibration, you need a force. To keep a vibration going, you need inertia, and you need a restoring force, a force that always is acting to pull the vibrating object to a center position. And this holds true for all vibrations, whether simple or as complex as those taking place inside an atom. Friction is the enemy of vibrations. Eventually, friction will slow down any vibrating object. If there were no friction, an object set vibrating would vibrate forever.

You don't need expensive equipment to get started doing experiments with vibrations. It was through Galileo's observation of the behavior of a simple pendulum that the modern scientific era was born. We will suggest some experiments using simple pendulums and vibrating springs which can give your students a good first insight into just what a vibration is.

As you do these experiments, keep in mind that what you learn about vibrations (using such simple devices as a pendulum, or a chain of rubber bands with a weight on it) will be extremely useful knowledge when you start considering more sophisticated vibrations. For example, those involved in radio and radar and in atomic physics.

Demonstration To Be Presented Before Showing the Film

Hook a rubber band around a book as shown in FIGURE THREE, page 42, and let the book vibrate up and down. Ask the class if that is a vibration. Now stretch the same rubber band around an empty cardboard box and place two pencils under it to act as bridges. (See FIGURE FIVE, page 43.) Strum the rubber band between the pencils. Ask the class if that is a vibration. Show them the vibrating rubber band. Ask the class if sound is caused by vibrations. Move the pencils closer together and strum the rubber band again. Ask the class why the sound is higher now. Does the change in pitch have anything to do with vibrations?

Experiments and Projects

1. Make a simple pendulum by tying a string to a small weight. Tie the other end of the string to a support, and start the

pendulum vibrating. Watch the vibration closely. Where is the speed of the pendulum greatest? What effect does inertia (the tendency for a moving body to keep moving) have on the pendulum as it passes the middle point of its swing? What is the effect of the restoring force (the force that is always pulling the vibrating object towards the center position) while the pendulum is moving away from the center position? What is the effect of the restoring force on the pendulum when it starts moving towards the center position? How long will the pendulum vibrate before it stops? What stopped the vibration?

2. Clocks and watches are devices that usually have two distinct parts in them. One part is something that vibrates, such as a hairspring or a pendulum. The other part is something that counts these vibrations and displays a number on a scale. Look inside an ordinary wrist watch with a magnifying glass and try to see how the vibrating mechanism is connected with the counting mechanism. Do the same thing with a pendulum clock, if one is available. The new battery-powered wrist watches don't tick; they hum. There is a tiny tuning fork inside this kind of watch. The hum is caused by the vibrating of the tuning fork. If you have one of these watches, or a picture of one*, try to determine how the vibrating tuning fork is connected to the counting mechanism.

3. It is easy to prove that sound is caused by vibrations of objects. When you strike a very large tuning fork, it is even possible to see the vibrations involved.

Take a silver spoon and tie a string to it so that the spoon hangs at the bottom of a V-shaped string support. (See FIGURE FOUR.) Hold the ends of the string with your fingers inside your ears. While in this position, let the spoon touch the edge of a table. You will hear bell-like sounds. The sound is caused by the vibrations in the spoon that are being transmitted to your ears through the string.

4. Phonograph records depend upon vibrations. This can be checked by observing the grooves of a phonograph record through a ten-power magnifying glass. Look carefully and see if you can find places where there is a lot of activity — that is, where there are lots of vibrations per second. These places will have more irregularities along the edges of the grooves. These irregularities set up vibrations in the needle, as it passes by. The number of vibrations per second affects what we call the pitch. A good way to demonstrate this is with a modern phonograph turntable that can operate at different speeds. Standard speeds are 78, 45, and 33 revolutions per minute. Use a 33 rpm record and play it at all three speeds. The higher the speed, the higher the pitch of the sound.

5. It is apparent to anyone who plays a musical instrument that, in general, the smaller the musical instrument, the higher the pitch of the note that it produces. Compare the piccolo with a French horn, for example, or the violin with a bass viol.

Another place where the effect of size on pitch is apparent is in a xylophone or marimba. Compare the size of the vibrating bars that make the low notes with those that make the high notes.

Another way to observe the effect of size on pitch is to find bottles of different sizes and arrange them in order of size, and blow across their tops to produce musical tones. What can you say about size and pitch?

6. Stretch a rubber band around a cigar box or any small cardboard box. Stick two pencils under the rubber band on one side of the box. (See FIGURE FIVE.) Strum the rubber band between the two pencil "bridges." You have a crude musical instrument. Tighten the rubber band by twisting it on the other side of the box and strum again. Has the sound changed? Study the effect of the length of the vibrating object on pitch by moving the pencil bridges farther apart. Strum the rubber band. Has the sound changed?

7. A good place to learn about the relations between musical tones and the size of the vibrating object is in an ordinary piano. Remove the cover and observe that the size and length of the strings increases as you go down to the lower notes. While the cover is off, press the "loud" pedal, and while it is down, sing a note into the piano. You will find that the piano responds by singing back the same note.

This time, press the key for the C one octave above middle C. Press it gently so that no sound is heard, and leave it pressed.

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*The Bulova Watch Company, 75-20 Astoria Blvd., Jackson Heights, New York.

While it is pressed, give middle C a sharp blow without using the pedal. You will hear the C above middle C ringing until you remove your finger from its key. The explanation is this: let's say that middle C corresponds to two hundred and fifty-six vibrations per second. Double that is five hundred and twelve vibrations per second, which corresponds to the C above middle C.

This last experiment indicates that middle C vibrates not only at a frequency of two hundred and fifty-six vibrations per second, but also is simultaneously vibrating at five hundred and twelve vibrations per second. It is this overtone of middle C which starts the C above middle C vibrating. In the same way, you can find out what other overtones middle C has. Or for that matter, what overtones any other note may have.

8. The *period* of a vibration is the time required for one complete vibration. The frequency of a vibration is the number of vibrations per second. Make a "seconds" pendulum by tying a small heavy object to a string one meter long. Time sixty vibrations of this pendulum. Now, quite independently, take another pendulum, built the same way, and adjust it so that it has the same period as the first one. That means that the total time for sixty vibrations is the same for the second pendulum as it was for the first. Now, we want to answer the question, "do these two pendulums have exactly the same period and frequency?" A simple but crucial experiment will answer the question. Suspend both pendulums from nearby but independent supports. Start both of them swinging in unison, then wait a little while. Chances are that before long you will observe that one is going in one direction while the other goes in the other direction. Of course, if their periods had been absolutely alike, they would have gone together forever. Wait a little longer and they will be in unison again. This idea, that two vibrations that are almost alike are together part of the time, and not together part of the time, is the basis of the phenomena of *beats*. You can take two strings on a guitar and tune them so that they are alike. But you will observe that if they are out of tune with each other by just the slightest amount you will hear "*beats*" when you pluck them both. What is happening is that part of the time the vibrations of the two strings are in step with each other, and part of the time they are out of step. The two strings are in step, then out of step, then in step, over and over again, producing what we call a beat.

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III. Energy

J. Light and ultraviolet radiation

Name and Description of Film	Other Grade Placements	Remarks
1. Color and Light:: An Introduction * Coronet, 1962; 11 min., color Characteristics of color formation by different kinds of light are demonstrated in a variety of everyday situations. Theatrical spotlights are used to show the effect of different kinds of light with opaque, transparent and translucent objects.	Gr. 9 - *	
2. How to Bend Light ** EBF, 1961; 11 min., color Uses visual devices and demonstrations to show how light can be reflected and bounced off objects, and to explain how mirrors, prisms, and lenses can be used to bend light.	Gr. 9 - **	
3. Learning About Light ** EBF, 1958; 8 min., black & white Depicts the need for light in order to see and illustrates the concepts of luminosity, reflection, translucency, transparency, opacity, and refraction. Shows by means of an animated drawing of a steamship that light cannot bend around the earth. Concludes by reviewing the basic concepts.	Gr. 9 - **	
4. Light and Color * EBF, 1961; 11 min., color Uses illustrations and experiments to explore the science of color, explaining what color is, how it is related to light, how the eye sees color, and how color can give us information about things.	Gr. 9 - *	

* Good
** Excellent

III. Energy - J. (continued)

Name and Description of Film	Other Grade Placements	Remarks
5. Light and What it Does EBF, 1962; 11 min., color Demonstrates through a series of simple problem-solving experiences, how light travels; how it is affected by different materials; what causes reflection and refraction; and how light is used in many every day activities. We see boys experimenting with a camera and light meter. They perform experiments which demonstrate reflection and refraction: with mirrors and other shiny surfaces and by observing that a thermometer in a tank of water appears to be bent or broken. They learn that magnifying glasses and telescopes bend light to make what we see look larger and far away things seem nearer.		No. eval. yet
6. The Nature of Light * Coronet, 1948; 11 min. Observes, through the eyes of two youngsters, the principles of reflection and refraction; studies light as a form of radiant energy; and explains these principles as applied to the science of optics.	Gr. 9 - * Gr. 11 - **	Use 1st half
7. Refraction * United World, 1951; 8 min., black & white Demonstrates refraction by such analogies as that of wheels moving from a smooth surface onto sand. Explains critical angle and total internal reflection and shows their applications in the submarine periscope and in binoculars.	Gr. 9 - ** Gr. 11 - *	Difficult

* Good
** Excellent

How To Bend Light

Film Summary

We see powerful spotlights cutting through the night sky. Light seems to travel in straight lines. And there is a simple experiment to prove that light does travel in straight lines. We see a boy and a girl adjust three cards with small holes cut in them, so that they can sight through the holes and see a light. The three cards have to be in a certain position. When the girl moves one, she can no longer see the light. The girl lines up the cards again so that she can see the light. Then she threads a string through the holes in the three cards. When the string is stretched tight, it makes a straight line from the light through the holes in the three cards. The light traveled along this straight line.

A large booth with a door in it has been constructed so that it is lightproof. Inside, with the door closed, there is no light at all. Now a hole is drilled in one wall, giving light a way to get into the dark room. Two spotlights are set up shining at this hole. If the light from the spotlights travels in straight lines, there will be two spots of light inside the dark room. We go inside the room and find that this is the case.

It is night. A spotlight is shining directly at a boy. The boy can see the light because it is traveling to his eyes in a straight line from the spotlight. When the spotlight is turned away from him, he can no longer see its light until it hits something. The girl steps into the beam of the spotlight and the boy can see the light where it hits the girl. The light travels from the spotlight to the girl in a straight line. When it hits the girl, it bounces off her face and coat back to the boy's eyes. In other words, the light has been bent.

The girl stands outside the lightproof room. Light from a spotlight hits her. If this light bounces off the girl in all directions, some of it will go through the hole in the wall of the lightproof room. An animated diagram helps us to see where this light should fall on the wall inside the dark room. We would expect to see an image of the girl upside down inside the room. We go inside the room and see that this is exactly what has happened. The dark room with a hole in one wall is identified as a camera obscura, the first kind of camera.

We look into the ground glass of a portrait camera and see that it bears several distinct resemblances to the camera obscura.

We look closely at several parallel beams of light. Using small mirrors, we can bend each beam so that the beams are concentrated at a single point. The same thing can be done with a single curved mirror. We see a large curved mirror that bends and concentrates light and heat from the sun. When a two-by-four is placed in the spot where the beams of light from the sun are concentrated, the wood bursts into flames. A cylinder of lead placed in this concentrated spot of light quickly melts.

A beam of light traveling from air into water is bent. Light bends when it passes from one material to another. We see how light bends when it passes from air to glass. We see what happens when beams of light are passed through specially cut pieces of glass, called prisms and lenses. We see several ways in which lenses are used to magnify objects. Another important use of a lens is to focus an image. Only when the lens is fitted onto a portrait camera is there a sharp image on the ground glass.

Introduction to the Film

It is not hard to prove that light travels in straight lines. One proof is shown in the film. But if all light traveled forever in straight lines that were never bent, then the world we live in would be a very much different place indeed. If the straight lines in which light travels were never bent, the only things we would see on earth would be objects that are sources of light, such as the sun or a fire, whose light travels directly to our eyes in a straight line. And that is all we would see. The only reason that we see an object that is not a source of light—a chair, for example—is that light travels to it in straight lines from a source of light, hits it, bounces off, and travels to our eyes in another straight line. In other words, the light hitting the chair is bent so that it reaches our eyes.

A very large percentage of the information that we pick up in our daily lives comes by way of our eyes. If we examine how the eye works, we find that it also has the ability to bend light and that it makes use of this ability to form images on the retina.

There are three ways to bend light. The simplest way is by *reflection*. When light hits a mirror, it is bent by reflection. When light hits a chair, it is also bent by reflection, but this is another form of reflection which we may call "diffuse." Usually, the word "reflection" is reserved for the kind of light-bending that an ordinary mirror can do.

Another way to bend light is by *refraction*. Light is usually bent by refraction when it passes from one material to another. For example, a beam of light passing from air to water is bent by refraction. Lenses work by refraction. The light passing through a lens is bent by refraction: once, when it passes from the air into the glass of the lens; and again, when it passes from the glass back into the air. Practically all microscopes and cameras utilize refracting lenses to bend light and form images.

There is one other way to bend light which is not as obvious as the other methods and which is not treated in this film. If you look at a distant street lamp through a silk umbrella, or through some other material with a fine mesh, you will see that the light from the distant lamp is spread out as it passes through the small openings of the mesh. This is *diffraction*. When light passes through a very small opening, it is bent by diffraction. Although diffraction is not as common as reflection or refraction, it plays a very important role in the construction of certain modern optical instruments, and is of great interest to scientists.

Demonstration To Be Presented Before Showing the Film

Turn out the lights in the film-viewing room. Turn on the projector and let it run with no film in it so that a beam of white light is projected onto the screen. Ask the class if the light is traveling from the projector to the screen in straight lines. (It seems to be.) Now ask the students to look at the beam of light from the side. Can they see the light? (Not very well.) Pound two blackboard erasers together in the beam of the light, making a cloud of chalk dust. Ask the class if they can see the light now. (Yes, easily.) Why can they see it now? (Because it's hitting the chalk dust.) But how does the light get to your eyes from the projector? Is it traveling in a straight line to do it, or is it bent? What bends it?

Experiments and Projects

1. In a room that is otherwise dark, aim a flashlight with a strong beam at a place where chalk dust from a couple of erasers has recently been scattered. We can see the chalk dust because light from the flashlight hits it and some of that light is bent back to our eyes. This is a kind of reflection. Even an ordinary piece of white cardboard can be used to illustrate this diffuse kind

of reflection. In a dark room, you can bounce light from the flashlight off the cardboard so that it goes in a new direction. The light will not bounce off the card as a sharp beam, but the light bent by the card will be quite enough to light objects in the dark room that would otherwise be unseen. Try the same experiment with cards of different colors. What happens?

2. This time, in the dark room, reflect the beam of the flashlight with a small mirror. Mirror reflection gives you a sharp beam. How many degrees do you have to turn the mirror to make the reflected light move ninety degrees? (45 degrees.) Put a piece of colored cellophane over the flashlight. What happens to the reflected beam?

3. An ordinary piece of glass allows light to pass, but at the same time it also serves as a mirror. In other words, it also reflects some light. Because it serves both as a window and as a mirror, we can check one of the simplest laws of image-formation by using a plain piece of glass. If you hold a candle one foot in front of a mirror, its image will seem to be one foot behind the mirror. Now use the ordinary piece of window glass as a mirror and get two identical candles. Place one candle one foot in front of the glass. Place the other one foot behind the glass so that the line joining the two candles is perpendicular to the plane of the glass. Now observe that if you light the candle in front of the glass, the candle behind also seems to be lit. Why? An interesting trick is to light both candles and then blow out the one behind the glass. To anybody on the front side of the glass, the rear candle seems lit, even though you see the smoke produced when it was blown out.

4. An ordinary home-size fish tank is useful for demonstrating how light is bent by refraction. Fill the tank with water, and, if possible, dye the water with a food color. Fluorescein dye, a fluorescent dye available from scientific supply houses, is better if you can get it. The dye will make beams of light shining into the tank more readily visible. The following experiments should be made in a dark room. Use an ordinary flashlight and shine it into the water perpendicularly. Does the beam bend as it enters the water? Now tilt the flashlight so that the light enters obliquely; that is, not making an angle of 90 degrees with the surface of the water. Can you see the bending of the light as it enters the water?

5. It is not difficult to build a small camera obscura that will work in the same way as the large one seen in the film. You need a shoebox or another box of similar size. Paint the inside of the shoebox black. Cut one of the small ends of the box completely off so that the box is open at one end. Cover this open end with some translucent material. Tracing paper will do, or one of the many translucent plastic materials now available. Punch a pinhole in the end of the box opposite the end covered with the translucent material. Hold the camera obscura in front of your face and look at the translucent screen. You may be able to observe an image of objects in front of the camera obscura formed by the pinhole on the translucent screen. If you are working in a room that already has quite a bit of illumination, it is best to look at an object that has a high luminosity. For example, use the camera obscura to look at a burning light bulb. You should see a sharp image of the bulb on the translucent surface. This image may be studied from the point of view of geometry—that is, is the image upside down? Is it inverted from left to right?

6. Build a second camera obscura following the directions outlined above, but this time, use a box with no side larger than three inches in height or width. Observe an image formed by the pinhole on the translucent material. Now enlarge the pinhole to a hole the size of a nickel. You will get a great deal more light on the translucent surface, but the image will be badly out of focus. Take an inexpensive magnifying glass and hold it in front of the hole. Move it back and forth until you have a bright sharp image on the translucent paper. The lens is bending the light that passes through it just enough, and in just the right ways to produce the sharp image. (The focal length of the magnifier has to be greater than the length of the box.)

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Light and Color

Film Summary

In a close-up view we see what happens when red, blue, and green paint are mixed. You get a brownish mess. But when you take a color wheel with red, blue, and green sections and spin it, you get a color that is very nearly white.

Sunlight is passed through a prism onto a screen. The light from the sun appears to be white, but when it passes through a prism, there are colors. Light and color seem to be connected.

A spotlight shines on a card painted different shades of gray. Why does the dark shade of gray look dark, and the light shade look light? Now we see a spotlight shining on a white card. By moving the spotlight farther and farther back from the card, the card changes from white to darker and darker shades of gray. When a lot of light is shining on the card, it looks light. When less light is shining on it, it looks gray. Looking again at the card with different shades of gray painted on it, it now seems likely that the dark gray part looks dark because it reflects only a little light back to our eyes, and that the light gray part looks light because it reflects more light back to our eyes.

We see two aluminum frying pans, one painted white, the other black. A powerful spotlight is aimed directly at each frying pan. After several minutes, break an egg on each frying pan. Only the egg on the black pan fries. Why? Because the white pan reflected away most of the light that hit it. The black pan absorbed the light and the heat that went along with the light.

The light shining from a spotlight is white, but we have seen that white light is made up of light of many different colors. Using three projectors, one projecting red light, one blue light, and one green light, we see that we can mix the colored lights together and produce white light.

A spotlight is lighting a boy. The light from the spotlight is white, but the light falling on the boy's face is red. Why? Because the light from the spotlight hits a red card and then bounces onto the boy's face. Apparently the red card is able to absorb all colors of light from the white light except the red, which it reflects. A blue card absorbs all colors except blue; a green card, all colors except green, etc.

When white light shines on a color wheel, we see all three colors — red, blue, and green. But when the wheel is lit by green light, we see the green section only. The red and blue sections look black. Why? Because the green section of the color wheel reflects green light back to our eyes, but the red section and the blue section both absorb all the green light that shines on them, and reflect no light back to our eyes. We look at the color wheel in blue light and red light also.

We look at three different chemicals. When each one is heated, it produces a flame of a different color. We see the spectra of several different materials. Every different kind of material has a different set of colors that go with it. These identifying colors can be used rather like fingerprints, for the purpose of identifying materials. These "color fingerprints" in science are used to determine what materials distant stars are made of.

Introduction to the Film

Color plays an interesting and useful role in our daily lives. The great variety of colors in nature is a real source of beauty and pleasure. But color also has functions other than aesthetic. There are certain kinds of information transmitted by color. For example, whether a tree is alive or dead can be told in part from the color of its leaves. Color can tell us whether we are about to eat chocolate ice cream or vanilla. The color of certain living creatures can give us information about their age or their state of development.

The fact that color can give us information is of great importance in physical science. We have learned that every element existing in nature has a different set of identifying colors. These colors can be produced when the element is heated. The science of spectroscopy is concerned with viewing these colors through optical instruments in order to identify elements. Since the information involved is carried by color, and since color is so closely related to light, it is possible to observe light from distant stars and determine, with a great deal of accuracy, of what elements these distant stars are composed.

There are two important aspects to color: one has to do with the light that shines on objects, and the other with what the objects themselves do to that light. Actually, there is a third important consideration to be taken into account when we discuss color. That has to do with what goes on in the eye and brain when we see color. The subject of color is a difficult one because there are so many unexplained things that have to do with this last step.

In this film we will accept the fact that the eye and brain can distinguish different colors of light without attempting to determine how it is done. We will be concerned here, first, with what color is, how color is related to light, and why an object of a certain color looks that color to our eyes. We also would like to know how rain drops can take the white light from the sun and produce the colored light of the rainbow. We would like to know what is the difference between a black object and a white one, and the difference between a red one and a blue one. And finally, we want to give some tentative hints about the role color plays in the identification of chemical elements.

Demonstration To Be Presented Before Showing the Film

Turn off the lights in the viewing room. Hold a piece of red cellophane in front of the lens of the projector. There is no film threaded through the projector. Turn the projector on. A beam of red light will be thrown on the screen. Ask the class what color the screen is. Some students may answer "red." Pull the red cellophane out from the beam of light. The screen goes white. Assert that the screen is white, not red.

Now hold a red book in the path of the projected beam at a point close to the lens where the light is intense. Advise the class that you are going to bounce light off the book onto a card. Do so, bouncing the light onto a card which the class has not previously seen. The card looks red. Ask the class what color the card is. Some student, remembering the trick you have just played, may answer that the card is white. Remove the book and bring the card into the beam of the projector so that white light hits it. The card is one which is painted or colored red.

Place the red cellophane in front of the lens again. Hold a book which the class has not previously seen in the beam of red light. The book looks black. Ask the class what color the book is. Remove the cellophane from the beam of light. In white light you can see that the book is bright green. It certainly seems that the color an object appears to be depends very much on the color of the light that is hitting the object.

Experiments and Projects

1. One of the differences between black and white is that black absorbs light, and white reflects it. Take two steel balls and paint one of them black and the other one white. Now set them close to one another on a piece of ordinary kitchen paraffin. Hold a heat lamp with a reflector very close to the two balls. See if you can determine which ball sinks into the paraffin faster. If the black ball sinks in faster, can you explain why?

2. A *photometer* is a device that can measure the amount of light falling on it. A simple photometer can easily be constructed in the classroom. You need two rectangular slabs of paraffin of the kind used in the kitchen, and a sheet of aluminum foil folded once so that the shiny side is on the outside. Sandwich the aluminum foil between the two paraffin blocks and seal the blocks together by heat or by using rubber bands. The photometer is complete. Darken the room. Place two small candles, such as birthday-cake candles, each about one foot from either face of the paraffin photometer. Now look at the paraffin photometer from one side. The edges of the two pieces of paraffin should look about equally bright. Notice that as the photometer is moved closer to one candle, the edge of the paraffin towards that candle looks brighter and the other edge looks dark by comparison. It is easy to find a point of balance by moving the photometer back and forth between the candles until the scattered light viewed along the edge seems equally bright on both sides. Now, place one candle a foot away from one face of the photometer and another candle two feet away from the other face. Of course, one side of the paraffin photometer will look much darker than the other. Now light up more candles on the dark side (where the candle is two feet away) and see how many lit candles you need at this distance to balance the intensity of the single candle one foot away. (You should need four.)

3. There is a basic difference between mixing colored paints and mixing colored lights. It is possible to find three colors of paint which can be mixed together in vary-

ing proportions to produce many of the colors of the rainbow. These three colors will be magenta, cyan, and yellow. (Or, as artists say, red, blue, and yellow.) If you mix them all together, you can get something that approaches black. But there is no way to mix them to get white. However, you *can* mix colored lights to get white. There are two ways you can do this. One way will require a phonograph, or anything that spins. Cut out a circle of cardboard. Punch a hole in the center so that it will fit on the phonograph as a record does. Now divide the circle into three equal wedge-shaped segments. Cover each of these segments with colored construction paper—one with red paper, one with blue, and one with green. Now place the color wheel on the phonograph and let it spin at its highest speed. The spinning color wheel should turn whitish to your eye.

Another way to produce white by mixing colored lights requires three good flashlights and some colored cellophane. Cover one flashlight with red cellophane, another with blue cellophane, and another with green. Now in a dark room, turn on all three flashlights. Shine them against a white screen and move them so that the three spots of color merge together. Where they merge, you should get something close to white light. Try mixing the red light and the green light together. You should get something close to yellow.

NOTE: There are many variables affecting the experiments outlined in this paragraph. If you cannot achieve a whitish light with the color wheel, try changing the percentages of the wheel covered by each color. For example, try covering more than a third of the wheel with blue and less than a third with red. In no case will you get a pure white. In the case of the three flashlights, you may have to use more than one thickness of cellophane on one or two of the flashlights in order to adjust the relative brightness of the colors.

4. The poem says that roses are red and violets are blue, but it's wrong on several counts. For one thing, everybody knows that violets are violet, not blue. But we are more interested in pointing out that while color is due in part to the object, it is also due in part to the light that hits the object. If the light that hits a red rose happens not to have any red in it, the rose will look black. If the earth's atmosphere were suddenly able to transmit only yellow light, for example, then every object around us would look either yellow or black. We can do some experiments by putting pieces of colored cellophane over the lens of a projector. Turn out the lights in the room, put a piece of blue cellophane over the lens and let the blue light shine on an American flag. Describe what you see. Now change to red cellophane. Now describe what you see. Finally, take yellow cellophane and put it over the lens, shine the light on the American flag, and describe what you see.

5. The easiest way to get colors from white light is to shine the light through a prism. Inexpensive prisms are available today at any scientific supply house. A crude prism can sometimes be improvised by using a piece of glass with several flat sides—a paperweight, perhaps. The first thing to do with your prism is to let sunlight pass through it. Adjust the prism so that the light hits a white card after it has passed through the prism. What colors do you see? In what order do the colors appear? Are they in the same order as the colors of the rainbow—that is, red, orange, yellow, green, blue, and violet?

6. If you sprinkle ordinary table salt into the blue flame of a kitchen stove, the flame will turn yellow. Table salt is a chemical called sodium chloride. A teacher or chemist can get other chemicals at a drugstore. Try lithium chloride, potassium chloride, and calcium chloride. NOTE: *These chemicals should be handled only under the supervision of a qualified teacher or chemist.* If you pour some of each of these chemicals into the flame, you will observe that the flame burns a different color for each different chemical. These colors are what might be termed the fingerprints of the chemicals: sodium, lithium, potassium, and calcium. Here at last we are using color in a very scientific way to give us information about the chemical make-up of different materials.

7. Everyone has seen the beautiful colors that are formed when there is oil floating on puddles on a dark pavement. A controlled laboratory experiment which produces the same colors can be made by painting a flat kitchen tray dull black and filling it with water. Place a piece of white cardboard vertically alongside the tray and

look into the tray so that you can see the reflection of the cardboard in the water. Now take some ordinary machine oil and, with a dropper, drop just one drop of oil on the surface of the water. As the oil spreads, you will see the beautiful colors associated with the phenomena we call *interference*. We are not going to explain interference here, but simply point out that this is another way in which colors are produced. Another example of interference is observed when we see colors in ordinary soap film. Almost any of the detergents used for washing dishes can produce very beautiful soap bubbles. Try to name some of the colors you see in the bubbles and try to compare the order of the colors as seen in the bubbles with the order of the colors that you see in the rainbow. Are there some colors in the soap film that you never see in the rainbow? (Yes.)

8. Polaroid sun glasses are sufficiently common these days so that you can get two pairs of them. Hold the two glasses one in front of the other, and rotate one relative to the other until almost no light passes through the double thickness of polaroid glass. Now take an ordinary piece of clear cellophane and put it between the two glasses. Chances are that light will come through now and that the light will be colored. You can examine many things this way. For example, transparent plastic coat hangers and plastic tape-recorder reels exhibit colors when viewed between two pieces of polaroid glass. We will not explain here what polarization is, but this will introduce you to still another way of producing colored light from white light.

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Energy - J. (continued)

Name and Description of Film	Other Grade Placements	Remarks
8. Science of Light * Churchill-Wexler, 1960; 11 min., color Presents various concepts about light and sight. Uses animation, photomicrography and the visualization of experiments difficult to do in the classroom in a discussion about refraction, the speed of light, how we see, where light goes, how light reflects from different surfaces, how it is absorbed and changed to heat, and how light is transmitted through opaque, translucent, and transparent materials.	Gr. 9 - **	

* Good
** Excellent

IV. The Universe

F. Space Travel

Name and Description of Film	Other Grade Placements	Remarks
1. ABC of Jet Propulsion ** Gen. Motors, 1959; 17 min., color An animated film which explains how a jet engine works and how it differs from other internal combustion engines.	Gr. 9 - ** Gr. 11 - * Gr. 12 - *	
2. Balance of Life and the Space Age ** Film Associates of Calif., ; 13½ min., color The film considers the earth's living things in terms of their basic needs. In a pond, plants use carbon dioxide supplied by fish, and fish use oxygen supplied by plants. Such a community of interdependent plants and animals is called a balanced system. Astronauts in today's space capsules must also be supplied with food and oxygen to keep them alive, but for long space journeys, it will be necessary to create a balanced system inside a space capsule in order to keep astronauts alive.		
3. The Big Bounce * N. W. Bell, 1961; 14 min., color This documentary shows the actual satellite communications experiments sponsored by the National Aeronautics and Space Administration. It reveals how this may lead to world-wide space communication systems of the future. The experiments of Bell Telephone Laboratories in New Jersey and the Jet Propulsion Laboratory in California are also shown.	Gr. 9 - ** Gr. 11 - *	

* Good
** Excellent

IV. The Universe - F. (continued)

Name and Description of Film	Other Grade Placements	Remarks
4. Earth Satellites--Explorers of Outer Space ** EBF, 1959; 17 min. Scenes at the Army and Navy launching site show satellites being built, prepared for launching, and taking off. Uses animated drawings to explain why satellites stay in orbit, how orbits may vary, and how information is received from satellites. Includes a sequence describing things to come in the space age.	Gr. 9 - **	
5. Gravity ** Coronet, 1950; 11 min., color Through a variety of everyday examples explains the force of gravity. Shows attraction in relation to mass and distance, and the effect of gravity on our solar system. Demonstrates and explains mutual attraction between all bodies.	Gr. 5 - ** Gr. 8 - ** Gr. 9 - **	Also listed III-C
6. Gravity - How It Affects Us ** EBF, 1960, 14 min., black & white Illustrates gravity's importance by showing some of the things that gravity does; its action upon our daily activities, its effects on our earth, and how it would affect a human being on an imaginary trip through outer space. Includes sequences on the experiments of Galileo and Isaac Newton.	Gr. 2 - ** Gr. 3 - ** Gr. 9 - **	Also listed III-C A little adv.

* Good
** Excellent

The Universe - F. (continued)

Name and Description of Film	Other Grade Placements	Remarks
7. Gravity, Weight and Weightlessness ** Film Associates of Calif., ; 11 min., color In lively and stimulating style, this film defines weight as the measure of the pull of gravity. Objects in free fall are shown to be weightless. Newton's classic experiment is demonstrated to show that a cannon ball fired with sufficient force will orbit the earth in free fall. A satellite orbiting the earth is also in free fall, and is therefore weightless. The film shows how space scientists are studying gravity, weight, and the effects of free fall and weightlessness in order to launch satellites into orbit.		
8. Magnetic, Electric and Gravitational Fields ** EBF, 1961; 11 min., color Uses animated drawings with live-action scenes to define the characteristics of fields and to illustrate their practical applications. Shows the effects of a magnetic field on a compass needle, of the earth's gravitational field on the moon's orbit, and of electric fields on materials such as wood, glass, and steel.	Gr. 4 - ** Gr. 5 - ** Gr. 9 - **	
9. Man in Space ** Walt Disney, 1957; 35 min., color Depicts the development of rockets from the ancient Chinese weapons to modern missiles, and shows how man may conquer outer space and establish a manned satellite 1,075 miles above the earth. Includes animated sequences.	Gr. 9 - ** Gr. 11 - **	Outdated

* Good
** Excellent

The Universe - F. (continued)

Name and Description of Film	Other Grade Placements	Remarks
10. Man and the Moon ** Walt Disney, 1959; 20 min., color This film presents a realistic and believable trip to the moon in a rocket ship - not in some far-off fantastic never-never land, but in the near, foreseeable future. It will provide food for sober thought for the mature viewer and stimulation and motivation for young people considering future vocations.	Gr. 9 - *	Outdated
11. Mars and Beyond ** Walt Disney, 1958; 30 min., color Discusses the temperature and atmosphere on the planets and the conditions necessary to sustain life. Explains man's earliest concepts of the planets, particularly Mars. Pictures the possible surface of Mars and the ways in which plant and animal life may have adapted to conditions there. Describes an imaginary flight to Mars in an atom-powered space ship.	Gr. 5 - ** Gr. 8 - ** Gr. 9 - **	
12. Rockets: How They Work ** EBF, 1958; 14 min. Uses animated models and drawings to show how rockets achieve motion, and compares rocket power with other types of motive power. Scenes at a rocket launching site show the count-down procedure and the take-off of a giant multi-stage rocket. Demonstrates the functioning of a rocket guidance system.	Gr. 9 - **	A little diff.

* Good
** Excellent

Magnetic, Electric, and Gravitational Fields

Film Summary

A thin piece of paper is placed over a permanent magnet, and iron filings are sprinkled on the paper. The filings arrange themselves in a pattern. Why do they form a pattern? Because each of the iron filings is affected by forces. The filings are affected by the force of the magnet, even though the magnet is not touching them. A region of space where at every point a force can be felt, is called a field. There is a magnetic field around every magnet.

When a small compass is brought close to the magnet, the compass needle is affected by the magnetic field. We look at the compass closely and see that the needle lines up in the same direction as the filings under it. As the compass is moved in relation to the magnet, the compass needle turns so that it is always lined up in the same direction as the filings under it. The magnetic field is affecting the compass, even though the magnet does not touch the compass.

We see several experiments indicating visually that the magnetic field around magnets is very real. We see one magnet pushing another uphill, even though the two magnets are not touching each other.

But a magnetic field does not affect a glass rod. We see that a glass rod cannot be attracted by the magnet. Nor can an old shoe. But a piece of plastic, after it has been rubbed with fur, can attract both the glass rod and the shoe without touching them. There is a field around the plastic after it has been rubbed with the fur, but it is not a magnetic field. Rubbing the plastic rod gave it an electric charge, and surrounding any object that has an electric charge is an electric field.

An electric generator in the shape of a sphere attracts a small paper cube tied to the end of a string. No matter where we move the cube around the sphere, the cube is always attracted toward the center of the sphere. The electric field seems to extend out from the spherical generator in all directions. When the paper cube on the end of the string is pulled too far away from the generator, it falls down. Why? The farther you are from the source of the electric field, the weaker it is. Finally, it is too weak to hold the paper cube up against the force of gravity. And gravity itself is another kind of field.

A series of live-action situations and animated drawings indicate that the earth, like all objects, is surrounded by a gravitational field. Wherever you stand on the earth, this field is pulling down towards the center of the earth. The gravitational field extends out away from the earth in all directions. At 239,000 miles away from the earth, it is still strong enough to keep the moon in orbit.

We look at an electromagnet. There is a magnetic field around it only when electric charges are flowing through the coil of the electromagnet. The electromagnet is turned on and off. A magnetic needle several feet away swings back and forth. It takes energy to make the magnetic needle move. That energy seems to be carried by the magnetic field.

Introduction to the Film

This film has to do with three things that are invisible: magnetic, electric and gravitational fields. These fields are not invisible the way atoms are invisible, simply because they are too tiny to be seen. Atoms at least have mass, and when they hit something they can push it. Magnetic, electric, and gravitational fields are spread out all over space and have no mass in the ordinary sense. But they can also push things, and it is because we can observe them pushing and pulling things that we know they do exist.

We live immersed in electric, magnetic, and gravitational fields, but we are often not aware of them because their effects are so commonplace that we take them for granted. Objects released from the hand fall towards the center of the earth because of the gravitational field around the earth. Magnetic compass needles swing around until they point in a northerly direction because of the magnetic field of the earth. The electric fields which are around the earth are seldom noticed at all because we seldom have occasion to observe them affecting an object we can see.

In general, a field is an area in space at every point of which a force can be felt. Around every magnet, there is a magnetic field. At every point in that field, the force of the magnet can be felt. Around every object with an electric charge is an electric field. At every point in this field, the attraction or repulsion of the electric force can be felt. And finally, around *every* object, big and small, there is a gravitational field. At every point in the gravitational field, the force of gravity can be felt, pulling towards the object around which the field centers.

Fortunately, for the purposes of study, we can make some of these fields visible. The easiest to work with are magnetic fields, because magnets are commonplace, and because the fields around magnets can be easily demonstrated in many different ways. One way is the well-known technique of sprinkling iron filings on a piece of paper beneath which a magnet has been placed. But there are other ways, and some will be described in the experiments below. One of the first things you notice about magnetic fields is that they affect only a certain class of objects. Ordinary magnets can pick up only iron and steel. Very strong magnets can attract nickel and some other metals with a weak force. But by and large, the number of different kinds of materials that are affected by magnetic fields is very limited.

By comparison, the effects of electric fields can be observed acting on almost any material. When you rub a plastic coat hanger with a silk cloth, both the hanger and the cloth are given electric charges. Because the two objects have electric charges, there are now electric fields around both of them. These fields can exert a force on almost any kind of object. Hang a banana from a thread so that it is free to pivot in a horizontal plane. Let it come to rest. Bring the charged coat hanger close to it. The banana will feel the force of the electric field around the coat hanger, and will move. You could replace the banana with any object of similar size and weight and observe the same effect.

The third kind of field is the gravitational field. It is very difficult to invent a way to make a gravitational field visible, although in a sense a simple plumb line—that is, a string with a weight attached to it—is an indicator for a gravitational field in quite the same way that a magnetic compass is an indicator for a magnetic field. Just hang a heavy object on a string and let it come to rest. The string ends up pointing in the direction in which the gravitational field pulls, and the tension in the string is a measure of the strength of the gravitational field. By comparison with electric and magnetic fields, gravitational fields are relatively weak. That may not sound correct, because you have seen how difficult it is to lift a heavy suitcase or a safe or an automobile against the force of gravity. The effect of the gravitational field of the earth on such objects is very large indeed, but that is because the earth itself is tremendous. What is not so easy to conceive is that there is a gravitational field around every object, whether it be the earth or an apple or a chair. If you hang two apples from strings and place them near one another, the apples will pull on each other. But the apples will not move. Why not? The answer is that the gravitational field around an apple is extremely weak, but we have good reason to believe that it exists nevertheless. (See EB Film, GRAVITY: HOW IT AFFECTS US, for a demonstration indicating that there are gravitational fields surrounding small objects.)

A very simple experiment proves that one object can be acted upon by all three kinds of fields. If you remove the needle from a magnetic compass (there are demonstration compass needles about six inches long which can be easily removed from their support) and tie a string to it and suspend the other end of the string from a fixed support, the weight of the needle will bring the string to rest pointing downward. In other words, gravity acts on the needle. Now put the needle back on its support so that it can rotate freely, and bring a charged object, such as a plastic coat hanger that has been rubbed with wool, close to the needle. You will see that the needle is attracted by the electric field around the coat hanger. Finally, if you bring a magnet close to the needle, you will see, of course, that the magnet attracts it.

Why are we so interested in fields? Fields play an important, if not immediately obvious, role in the transmission of energy and information from one place to another. For example, the light we receive from the sun and the signals we receive on our radio or television receiver come to us by means of electric and magnetic fields. The interrelation and control of magnetic and electric fields in the circuitry of electronic mechanisms plays an important role in our technology and science. And certainly, as the exploration of space becomes a reality, a detailed knowledge not only of gravitational fields but also of the electric and magnetic fields that exist in space will be of prime importance.

Demonstration To Be Presented Before Showing The Film

Place a pane of glass, or a piece of cardboard, over the most powerful U-shaped magnet you can find. Sprinkle small tacks or nails on the glass or cardboard surface. (See FIGURE TEN.) Sprinkle lots of tacks. Observe that they pile up in mounds which are concentrated near the poles of the magnets, but that the tacks also form an arch through space between the two poles. Ask the class what holds the nails up in that arch. (The magnet.) How does the magnet affect objects that do not touch it? Is there something special about the area of space around a magnet?

Experiments and Projects

1. Iron filings are available from scientific supply houses. Place a thin sheet of paper over any magnet and sprinkle the filings evenly across the paper. Putting the filings in an old salt shaker makes a convenient way to handle them. You can get many interesting pattern variations by using several magnets arranged in different relationships to each other. Or you can place a non-magnetic iron object, a washer for example, in the field of a magnet, cover both with paper, sprinkle filings, and see what sort of pattern you get. Also try this last variation of the experiment by placing in the magnetic field an object that is not affected by magnetism—a coin, for example.

2. Another way to plot a magnetic field is to use a compass. Find the smallest compass you can. Tape a bar magnet on the underside of a wooden table-top. Place a large sheet of paper on top of the table. Place the compass anywhere on the paper. The needle will point towards the hidden magnet. Make a dot with a pencil against the circular edge of the compass at the spot where the needle points. Now, move the compass a length equal to its own diameter, in the direction in which the needle was pointing, and make a dot where the point of the needle now comes to rest. Continue doing this and connect the dots with a solid line. You will get a curve which ends at one of the poles of the magnet. By starting at random places on the paper you will get a succession of such curved lines. If you plot enough of them, you will get a pattern similar to the kind formed by the iron filings.

3. Stand and brace a powerful U-shaped magnet so that it rests with the two ends of the magnet pointing up. Place a pane of glass on top of the magnet. (See FIGURE TEN.) Sprinkle small tacks on the glass over the magnet. Observe that the tacks, if you pour enough of them and if the magnet is strong enough, will form an arch through space between the poles of the magnet. The magnetic field must extend through the pane of glass. Repeat the experiment substituting thin sheets of other materials for the glass—cardboard, wood, aluminum. (An aluminum frying pan will do.) Do any of these objects affect the magnetic field? Now try an iron or steel frying pan. Does the arch of tacks form again or does the iron do something to contain the field around the magnet? (The magnetic field is concentrated within the iron of the frying pan.)

4. Electric fields work on anything. You can suspend any sort of object you like (try a shoe or a carrot, for example) and attract it or repel it with an electric field. The hanging object must be suspended in such a way that it is free to rotate in a horizontal plane. (See FIGURE ONE, page 23.) Give another object a charge by rubbing it and use the electric field around the charged object to attract the hanging object. Try a wide variety of objects, both to be attracted and to be given the charge. If you try a wide enough variety, you will see that glass, metals, wood, plastics—in fact, anything and everything can be affected by electric fields.

5. The machine in the film which produces an electric field around a metal sphere is called a Van de Graaff generator. Toy working versions of these generators are available. Perhaps one of your students has one and can bring it to class for experiments. The Van de Graaff generator is not dangerous. However, you should not touch the metal sphere when the machine has an electric charge on it. It is not dangerous to touch it, but it will give you a shock. You can explore, and, in a sense, plot the electric field around a charged Van de Graaff generator with a cornflake tied to the end of a fine thread. Hold the thread so that the cornflake is attracted towards the metal sphere. The string will be pulled toward the center of the sphere, indicating the direction in which the electric field is pulling. Move the string and cornflake around the Van de Graaff generator. It will always point towards the center of the sphere.

6. Fields can transmit information from one place to another. A radio signal is a good example of this. Radio signals are made up of a combination of magnetic and electric fields. It is not difficult to set up an experimental example of a field transmitting information. For example, take an electromagnet and a compass. The electromagnet can be home-made. Simply wrap insulated copper wire around a large iron nail. The more wire you wrap around the nail, the better. Attach one end of the wire to one post of a dry cell. When you touch the other end of the wire to the other post, you will have an electromagnet. Place the

compass on a wooden table. Place the electromagnet a foot away with the nail pointing towards the compass. Have one student stand at one end of the table watching the compass. Have another student stand at the opposite end of the table, ready to work the electromagnet. Have two more students hold a large piece of cardboard or plywood so that it rests on the table between the compass and the electromagnet, and so that it hides the other two students from each other. If the student at the electromagnet briefly completes the circuit by touching the wire to the post of the dry cell, the student watching the compass will know it, even though he cannot see it happen. He will know because he will see the compass needle move. Information has been transmitted by a field, in this case a magnetic field. It would be easy to develop a simple code so that more elaborate information could be transmitted in this way.

7. If you try to attract aluminum with a magnet, you will fail. But there is a way to demonstrate that a magnetic field does have some effect on aluminum, although it is a very weak one. Take a bar magnet and suspend it from a vertical string so that it hangs horizontally and can rotate in a horizontal plane as it twists. Now get a phonograph turntable and a flat piece of aluminum—for example, an aluminum pie tin. Place some books on the phonograph turntable so that the aluminum pie tin will be a good distance away from the turntable itself when it is placed on top. Now place the turntable beneath the hanging magnet so that the axis of the turntable coincides with the line represented by the string that holds the magnet. (See FIGURE ELEVEN.)

Allow the string to untwist so that the magnet is absolutely still in a horizontal plane. Now start the turntable going so that the aluminum disk rotates directly beneath the magnet. After a while the magnet will start turning. There is some sort of interaction between the aluminum and the field of the magnet. The effect is difficult to explain in detail, although we can say that the link is electric currents in the aluminum which produce magnetic effects, which in turn affect the magnet.

Correlated References for Students and Teachers

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pp. 133-150

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Unit 7, pp. 224-259

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Scott, Foresman and Co., 1957
Unit 3, pp. 105-107

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Scott, Foresman and Co., 1957
Unit 3, pp. 121-152

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Scott, Foresman and Co., 1957
Unit 9, pp. 192-216
Unit 10, pp. 230-231
Unit 16, pp. 387-393

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The Physical World
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White, Harvey E.
Physics: An Exact Science
D. Van Nostrand Co., Inc., 1959
pp. 386-390, 401-404

Space Travel - F. (continued)

Name and Description of Film	Other Grade Placements	Remarks
13. Rockets: Principles and Safety ** Film Assoc. of Calif., 1959; 11 min. Describes the physical principles upon which rockets work; explains why rocket motors can work in the absence of air; and stresses that rockets are dangerous and should not be built or fired by amateurs.	Gr. 9 - **	A little diff.
14. Satellites: Stepping Stones to Space ** Film Assoc. of Calif., 1959; 18 min. Through animation, models and live action photography the film shows the construction and instruments of Explorer I and explains how it was put in orbit. Demonstrates why satellites stay up, what determines their lifetimes, and how they record information.	Gr. 9 - **	
15. Screen News Digest--Volume 4, Issue 8 ** *(Flight of Friendship 7)* Hearst Metrotone News, 1962; 20 min., black & white Covers the Flight of the Friendship 7 which includes a hero's welcome...happy landings...in orbit...in the Friendship 7...a moment of prayer ...three...two...one.	Gr. 9 - **	

* Good
** Excellent

Space Travel - F. (continued)

Name and Description of Film	Other Grade Placements	Remarks
16. A Trip to the Moon ** EBF, 1957; 16 min. Shows an imaginary rocket as it takes off to the moon and hovers above it, explaining many facts necessary for an understanding of navigation to the moon. Combines animation and model photography to study the moon's surface, and shows in detail the craters and seas, ridges and mountains that can be seen from the earth.	Gr. 5 - ** Gr. 8 - ** Gr. 9 - **	
17. U. S. Space Pioneer * Nat'l Cinema Serv., 1962; 8 min., black & white News reel pictures of Alan Shepard's flight in outer space.		

* Good
** Excellent

SCIENCE MOTION PICTURE FILMS - Grade Six
(Addendum)

IV. The Universe

F. Space travel

Name and Description of Film	Other Grade Placements	Remarks
Mission - 22 Orbits ** U W F, 1963; 9 min., b/w Uses newsreel footage to show various phases of the manned orbital flight made by Major Gordon Cooper in his Faith 7 capsule on May 15-16, 1963. Includes views of the carrier Kearsarge and the operations involved in releasing Major Cooper from the capsule after 22 orbits.		
Why Explore Space? ** Churchill Films, 1962; 16 min., color Raises questions in both science and social studies, discussing the values of space research, the relationship of space research to world problems, the goals of science, how new knowledge of science will change life. Includes views of the flight of John Glenn.		

* Good
** Excellent
4-18-66

SCIENCE MOTION PICTURE FILMS - Grade Six

(Deletions)

No. and Name of Film	Page No.	Reason
Introduction to Science		
1. Horizons Beyond	1	Removed from circulation by AV Dept.

4-18-66

For discussion purposes only

SCIENCE FILMSTRIPS

(35 mm.)

for
Grade Six

Correlated to the Major Topics as found in the
Reorganized Science Curriculum

Minneapolis Public Schools
Science Department
12-1-64

TABLE OF CONTENTS

Unit Title	Page Number	Color
Fall		
Introduction to Science		
A. Attitudes (including history)	1	Gray
B. Tools	2	Gray
Fall and Winter		
III. Energy		
L. Chemical energy	3	Yellow
C. Mechanical energy and simple machines	5	Yellow
J. Light and ultraviolet radiation	7	Yellow
Spring		
IV. The Universe		
F. Space travel (includes some aviation, space biology, gravitational energy and mechanical energy)	9	Blue

The annotations for filmstrips found on the following pages were obtained from sources such as the Wilson's *Filmstrip Guide*, producers' catalogs, and the Library of Congress cards.

Fall

Introduction to Science

A. Attitudes (including history)

Name and Description of Filmstrip	Other Grade Placements	Remarks
1. Scientists at Work * American Gas Association Educational Service Bureau, 46 fr., b/w $ Designed to show an image of the scientist. His contributions and procedures are stressed. Thinking, designing experiments & recording data are emphasized. Activities such as life of keeping up-to-date & reporting his work are discussed. Natural gas and science occupations are related at the close of the strip.	Gr. 4 ** Gr. 7 * Gr. 8 *	

* Good
** Excellent

Introduction to Science

B. Tools

Name and Description of Filmstrip	Other Grade Placements	Remarks
1. The Amazing Electron Microscope * McGraw-Hill Book Co., 1957; 40 fr., color (General Science Series, Set 3, 6 f.s.) $6.75 each, $36.50 set Compares the optical with the electron microscope; describes the basic principles of the electron microscope and studies its structural parts. Shows some photographs made through the electron microscope and examines some of its practical applications.		

* Good
** Excellent

Fall and Winter

III. Energy

L. Chemical energy

Name and Description of Filmstrip	Other Grade Placements	Remarks
1. Atoms and Molecules ** Row-Peterson Textfilms, 1958; 46 fr., color Basic Science Education Series (Elementary Chemistry Group), 3 f.s., $6.00 each The atom as the basic unit of a chemical element. Molecules of various elements; physical structure of solids, liquids, gases; use of clay-ball models to explain atoms, molecules, compounds, mixtures; chemical formulas; testing of ability to recognize and identify elements, mixtures, compounds through use of color-keyed models of molecules; inner structure of atoms; nuclear fission, with release of energy.		
2. Chemical Changes * Row-Peterson Textfilms, 1958; 42 fr., color Basic Science Education Series (Elementary Chemistry Group), 3 f.s., $6.00 each Physical changes and chemical changes -- Meaning of chemical formulas -- Ways of bringing about chemical changes -- Identification of physical and chemical changes in everyday life -- Prevention of chemical changes.		
3. How Do Jets Fly? ** Jam Handy Organization, 1960; 40 fr., color (Airplanes, Jets and Rockets Series, 6 f.s.) $5.75 each Paintings and drawings -- How a jet engine works -- Examples and experiments demonstrating the principle of action and reaction, the sound barrier, advantages of jets over propeller-driven planes.	Gr. 9 - **	Also listed IV-F

* Good
** Excellent

III. Energy - L. (continued)

Name and Description of Filmstrip	Other Grade Placements	Remarks
4. Rocket Power for Space Travel ** Jam Handy Organization, 1960; 40 fr., color (Airplanes, Jets and Rocket Series, 6 f.s.), $5.75 each Paintings and drawings. How a rocket works in airless space. Multistage rockets; rocket planes; why satellites and space stations orbit. Problems of space travel in the future.	Gr. 9 - *	Also listed IV-F
5. What Things Are Made Of ** Row-Peterson Textfilms, 1958; 43 fr., color Basic Science Education Series (Elementary Chemistry Group), 3 f.s., $6.00 each Definition of chemical element; properties of elements; uses of substances in elemental form; possibility of combining elements into compounds; elementary language of chemistry; simple compounds and the elements that compose them; properties of common compounds as being different from properties of the elements that compose them; appearance of a compound; properties of elements; mixtures.		

* Good
** Excellent

III. Energy

C. Mechanical energy and simple machines

Name and Description of Filmstrip	Other Grade Placements	Remarks

1. Levers at Work **

Jam Handy Organization, 1964; 43 fr., color
(Work, Friction and Machines Series, 6 f.s.)
$5.75 each, $31.50 set

A lever is a rigid bar pivoting on a point called the fulcrum. The force needed to lift a weight can be reduced by moving the fulcrum closer to the weight. By changing the position of the fulcrum, the direction of an applied force can be changed, the effect of the applied force can be increased, or an object can be moved farther and faster with an increased force.

2. Pulleys at Work **

Jam Handy Organization, 1964; 43 fr., color
(Work, Friction and Machines Series, 6 f.s.)
$5.75 each, $31.50 set

A pulley is another simple machine which makes it easier to raise an object. A fixed pulley changes the direction of the force. A movable pulley reduces the applied force needed to raise a weight. A block and tackle, by combining a fixed pulley and a movable pulley, reduces as well as changes the direction of the applied force. By increasing the number of supporting strands on a block and tackle, the effectiveness of the block and tackle is increased.

* Good
** Excellent

III. Energy - C (continued)

Name and Description of Filmstrip | Other Grade Placements | Remarks

3. Screws and Wedges at Work *

Jam Handy Organization, 1964; 38 fr., color
(Work, Friction and Machines Series, 6 f.s.)
$5.75 each, $31.50 set

Screws and wedges are forms of inclined planes. Often screws are used to raise or move objects. With screws a small force moving a relatively long distance is used to move an object a short distance. Because of friction, screws and wedges can be used as holding devices rather than machines.

4. Simple Machines *

Row-Peterson Textfilms; 50 fr., color
Basic Science Education Series (General Science Group), 3.f.s., $3.00 each

Machines make work easier. There are six kinds of simple machines. Some machines can move an object in one direction by pushing or pulling in another direction. In some simple machines speed is traded for force. In some simple machines force is traded for speed. Many tools or machines are combinations of two or more simple machines.

5. Wheels and Axles at Work *

Jam Handy Organization, 1964; 38 fr., color
(Work, Friction and Machines Series, 6 f.s.)
$5.75 each, $31.50 set

With a wheel and axle we can overcome a large resistance with little force. The force applied to the wheel moves a greater distance than the resistance. The larger the wheel, the less the force needed to overcome a given resistance. A crank is a form of wheel and axle.

 * Good
** Excellent

III. Energy

J. Light and ultraviolet radiation

Name and Description of Filmstrip	Other Grade Placements	Remarks
1. What is Light? * Benefic Press, 1961; 34 fr., color (What Is It Series, 6 f.s.) $ Presents basic facts about light.	Gr. 9 - *	

* Good
** Excellent

Spring

IV. The Universe

F. Space travel (includes some aviation, space biology, gravitational energy and mechanical energy)

Name and Description of Filmstrip	Other Grade Placements	Remarks
1. Conditions In Space ** Jam Handy Organization, 1962; 41 fr., color (Space and Space Travel, 6 f.s. in series) $5.75 each Atmospheric pressure, sound, light and temperatures are discussed in terms of outer space. Cosmic rays, meteoroids, atomic fragments and magnetic fields in space are also examined.	Gr. 9 - **	
2. Exploring the Moon ** EBF, 1961; 29 fr., b/w, (Scanning the Universe Series, 7 f.s.), $3.00 each Uses photographs of the moon to depict and describe its topography, its phases and its relationship with the earth. Points out the most important features of the lunar landscape.	Gr. 8 - ** Gr. 9 - **	
3. Exploring the Moon ** Jam Handy Organization, 1962; 39 fr., color (Space and Space Travel Series, 6 f.s.), $5.75 each This filmstrip shows how a moonship could be built and launched from the orbit of a manned space station. The moonship is described in detail. A possible route to the moon is investigated. Some of the features of the moon are illustrated.	Gr. 9 - **	

* Good
** Excellent

IV. The Universe - F (continued)

Name and Description of Filmstrip	Other Grade Placements	Remarks
4. Getting Ready For A Space Trip ** Jam Handy Organization, 1961; 29 fr., color (First Adventures in Space Series, 6 f.s.) $5.75 each Drawings. Shows a young boy putting on the different parts of a space suit. Children watch him in testing machines such as the centrifuge, rocket sled and other devices.		
5. How Do Helicopters Fly? ** Jam Handy Organization, 1960; 33 fr., color (Airplanes, Jets and Rockets Series, 6 f.s.) $5.75 each Drawings and paintings. How the rotary wing provides both lift and thrust for a helicopter. How the pilot controls the helicopter. Various types of helicopters and the many important jobs they can do.	Gr. 9 - **	
6. How Do Jets Fly? ** Jam Handy Organization, 1960; 40 fr., color (Airplanes, Jets and Rockets Series, 6 f.s.), $5.75 each Paintings and drawings. How a jet engine works. Examples and experiments demonstrating the principle of action and reaction. The sound barrier. Advantages of jets over propeller-driven planes.	Gr. 9 - **	Also listed III-L

* Good
** Excellent

IV. The Universe - F (continued)

Name and Description of Filmstrip	Other Grade Placements	Remarks
7. How Is An Airplane Controlled? ** Jam Handy Organization, 1960; 29 fr., color (Airplanes, Jets and Rockets Series, 6 f.s.) $5.75 each Paintings and drawings. How the elevators, rudder, ailerons and flaps are used in controlling a plane. How the pilot operates these control surfaces to maneuver his plane.	Gr. 9 - **	
8. Man's Preparation for Space Travel ** Jam Handy Organization, 1962; 41 fr., color (Space and Space Travel Series, 6 f.s.) $5.75 each The problems of space travel, how a spaceship may be provided with air pressure and a continuing supply of oxygen, preparing for abnormal and zero gravitational forces, extreme heat, and a safe return to earth are presented in this filmstrip.	Gr. 9 - **	
9. Rocket Power For Space Travel ** Jam Handy Organization, 1960; 40 fr., color (Airplanes, Jets and Rockets Series, 6 f.s.) $5.75 each Paintings and drawings; how a rocket works in airless space; multistage rockets; rocket planes; Why satelites and space stations orbit, Problems of space travel of the future.	Gr. 9 - **	Also listed III-L
10. Rockets to Space ** Jam Handy Organization, 1961; 30 fr., color (First Adventures in Space Series), 6 f.s. $5.75 each Paintings. Shows the physical make-up of the rocket from the time it is enclosed in its gantry until its payload is orbiting in space.		

* Good
** Excellent

IV. The Universe - F (continued)

Name and Description of Filmstrip	Other Grade Placements	Remarks
11. **Safety in Flight** ** Jam Handy Organization, 1960; 37 fr., color (Airplanes, Jets and Rockets Series, 6 f.s.) $5.75 each Drawings and paintings. How the study of weather and the use of scientific instruments such as radar and instrument landing systems contribute to the safety of air travel.	Gr. 9 - *	
12. **Space Rockets** ** Jam Handy Organization, 1962; 43 fr., color (Space and Space Travel Series, 6 f.s.) $5.75 each The basic principles of rocket propulsion, the differences between solid and liquid fuel rocket engines, and the solution to man's problem of overcoming the earth's gravity are presented in detail.	Gr. 9 - **	
13. **Space Satellites** ** Jam Handy Organization, 1962; 40 fr., color (Space and Space Travel Series, 6 f.s) $5.75 each The basic principles governing the movement of satellites in space are portrayed, as well as the means by which satellites are put into orbit. Elliptical orbits, changing orbits, orbital decay, uses of satellites and other concepts are illustrated.	Gr. 9 - **	

* Good
** Excellent

IV. The Universe - F (continued)

Name and Description of Filmstrip	Other Grade Placements	Remarks
14. A Space Trip to the Moon Jam Handy Organization, 1961; 30 fr., color (First Adventures in Space Series - 6 f.s.) $5.75 each Paintings. Pictures the probable clothing and transportation needed to make a trip to the moon. Discusses known conditions on the moon and their effect upon man.		
15. Space Stations ** Jam Handy Organization, 1962; 41 fr., color (Space and Space Travel Series, 6 f.s.) $5.75 each The means and the principles involved in putting huge space stations into or bit are presented--how the station could be built in space, how pseudo "gravity" may be provided by rotating the wheel-like station and the advantages of such a station.	Gr. 9 - **	
16. Using Compressed Air * Visual Sciences, Suffern, N. Y., 1953 25 fr., color, $19.50 set (Air-#533 series, 5 f.s.) Drawings are used to demonstrate the practical everyday uses of compressed air and to show how compressed air is used in musical instruments, children's toys, tires, spray guns, and other commercial products.	Gr. 4 - **	For slow learners Listed under I.-F
17. What Are Satellites? ** Jam Handy Organization, 1961; 28 fr., color (First Adventures in Space Series, 6 f.s. $5.75 each Paintings. Shows how a satellite is put into orbit, how satellites are useful to man, and how a man-carrying satellite may be orbited and brought back to earth.		

* Good
** Excellent

IV. The Universe - F (continued)

Name and Description of Filmstrip	Other Grade Placements	Remarks
18. What Are Space Stations? ** Jam Handy Organization, 1961; 28 fr., color (First Adventures in Space Series, 6 f.s.) $5.75 each Paintings. Shows how a space station may be assembled in orbit. Illustrates the living and working quarters of a space station, and explains how man can make use of the station.		
19. What Is a Rocket? Benefic Press, 1961; 34 fr., color (6 f.s. in series) Presents basic facts about rockets.	Gr. 9 - *	
20. What Makes an Airplane Fly? Jam Handy Organization, 1960; 42 fr., color (Airplanes, Jets and Rockets Series, 6 f.s.) $5.75 each Drawings and paintings. How the propeller and the wing are designed to enable an airplane to fly. The four forces at work during the flight. Experiments with air pressure to show its role in flight. Examples of the ways in which airplanes serve man.	Gr. 9 - **	

* Good
** Excellent

JP:gm
2-4-64

QUIP. & SUPPLIES

BASIC SCIENCE SUPPLIES FOR ELEMENTARY SCHOOLS February 1966

Item No.		Unit	Unit Price
32-0140	ALCOHOL, Denatured	quart	.34
17-0100	ALUMINUM FOIL, 15" x 50', to waterproof table tops	roll	.62
17-0110	ALUMINUM FOIL, 18" x 50', for use under an aquarium or terrarium	roll	1.03
28-0100	ANIMAL PEN, 18" x 24" x 18" high	each	6.61
28-0105	ANIMAL PEN, cage, 9" x 9" circular	each	4.55
28-0110	ANT HOME, Turtox 220A167	each	7.50
	AQUARIUMS, TERRARIUMS AND SUPPLIES:		
28-0030	ACID NEUTRALIZER	ounce	.45
28-0040	AERATOR, Saxon	each	6.00
28-0200	AQUARIUM, 3 gallon, seamless	each	6.34
28-0300	AQUARIUM, 6 gallon	each	9.07
28-0340	AQUARIUM CEMENT	lb.	.60
	AQUARIUM COVER (include pattern w/requisition)		
28-0390	9-7/8" x 5-3/4", clear plexiglass	each	.42
28-0400	9-7/8" x 5-3/4", glass, double strength	each	1.00
28-0490	9-1/2" x 17-1/2", clear plexiglass	each	1.27
28-0500	9-1/2" x 17-1/2", glass, double strength	each	1.23
28-0600	AQUARIUM AND TERRARIUM SEALER	tube	.30
28-2100	CHARCOAL, Chunk	5# bag	.43
28-3000	DIP NET, 3" wide, 3-1/2" deep	each	.35
28-3020	DIP TUBE, plastic, 16", no scraper attachment	each	.90
28-3025	AQUARIUM METAL SCRAPER, long handle	each	.60
28-3290	FEEDING RING, 2"	each	.20
47-3260	GLASS SCRAPER, all metal	each	.18
47-0340	BLADES for above scraper	each	.02
28-4160	GRANITE CHIPS	lb.	.034
28-4180	GRAVEL	lb.	.05
28-7460	SAND	lb.	.15
28-8100	SOIL, sterile	bushel	1.50
28-9320	TEMPERATURE CONTROL OUTFIT: Thermostat #340 to include one of the following:	each	5.85
28-4310	PENCIL HEATER, 25 w, for aquarium, 1 to 3 gallon	each	2.00
28-4320	PENCIL HEATER, 50 w, for aquarium, 4 to 6 gallon	each	2.00
28-4330	PENCIL HEATER, 75 w, for aquarium, 7 to 15 gallon	each	2.75
28-0700	ASPIRATOR, Chapman pump, Cenco 13205-3, w/adapters to connect to sink	each	3.25
28-0705	HOSE FOR ASPIRATOR, black (indicate footage needed)	ft.	.27
28-0800	BALANCE, demonstration, clamp and support only (must order meter stick #28-5380 to complete set)	each	2.60

BASIC SCIENCE SUPPLIES FOR ELEMENTARY SCHOOLS

Item No.		Unit	Unit Price
28-0820	BALANCE, TRIPLE BEAM, stainless steel, capacity 610 gms Note: by use of auxiliary weights this balance can be used to a maximum of 2610 gms	each	15.35
28-0825	AUXILIARY WEIGHT SET, for use with Triple Beam Balance. Increases capacity from 610 gms to 2610 gms. Set consists of 2 1,000 gm weights and 1 500 gm weight.	set	4.50
28-0830	WEIGHT, 500 gm, for use with Triple Beam Balance (to replace any lost in Auxiliary Weight Set)	each	1.50
28-0835	WEIGHT, 1,000 gm, for use with Triple Beam Balance (to replace any lost in Auxiliary Weight Set)	each	1.50
28-0840	BALL AND RING	each	4.11
15-1200	BALLOONS, rubber	doz.	.46
28-0900	BAROMETER, ANEROID, 6" diameter, round wooden case	each	3.33
28-2150	BATTERY CELL HOLDER for "D" dry cell, mounted on board with Fahnestock clips for easy connection	each	.50
	BEAKER, Griffin, low form, Pyrex		
28-0940	100 ml	each	.40
28-0960	150 ml	each	.39
28-0980	250 ml	each	.39
28-1000	400 ml	each	.46
28-1020	BEAKER, Griffin, low form, stainless steel, 600 ml	each	2.97
28-1030	BELL, DOOR, electric, D.C., 2-1/2" diameter	each	1.64
28-1060	BELL OUTFIT, electric, dry cell, push button, 1 lb annunciator wire and staples	each	4.12
28-1500	BOTTLES, 4 oz. wide mouth (gas collecting bottle)	doz.	.66
28-1520	BOTTLES, 8 oz. wide mouth (gas collecting bottle)	doz.	.89
28-1540	BOTTLES, 4 oz. (baby food jar type with bakelite screw cap)	doz.	1.61
28-1570	BROM THYMOL BLUE, Crystaline, Free acid form, Harleco #862 (to detect the presence of carbon dioxide -- for the study of the constituents of air and the respiratory activities of plants and animals)	1-gram bottle	1.50
28-1600	BRUSH, Test tube, 3/4" x 3-1/2"	each	.13
28-1620	BURNER, Alcohol lamp, glass, 4 oz.	each	.74
28-1640	BURNER, Turner, liquid petroleum, tank + LP, Bunsen-type	each	7.95
70-4550	REPLACEMENT TANK	each	.98
28-1700	BUZZER, electric	each	1.73

BASIC SCIENCE SUPPLIES FOR ELEMENTARY SCHOOLS

Item No.		Unit	Unit Price
28-2010	CALCIUM HYDROXIDE SOLUTION, limewater (Also see Lime Water Tablets #28-4810)	1# bottle	.60
28-2030	CANDLES, Paraffin	doz.	.18
28-2040	CASTER CUPS, glass	each	.10
28-2050	CAT'S SKIN, half	each	3.64
28-2060	CELL, student's demonstration	each	3.15
28-2110	CHIMNEY, lamp	each	1.00
28-2120	CLAMP, Burette	each	1.20
28-2140	CLAMP, pendulum	each	2.30
28-2160	CLIP, Fahnestock, to be used to mount electrical apparatus (10 in package)	pkg.	.17
28-2200	COMPASS, magnetic, 16 mm diameter	each	.25
28-2240	COMPASS, magnetic, about 45 mm diameter	each	.70
28-2300	COMPOUND BAR, bi-metal	each	.78
28-2400	CONDUCTOMETER, four 5" wires on handle, overall length 13 inches	each	2.05
28-2500	CORKS, assorted, xx quality, sizes 0-11 (100 in bag)	bag	1.35
28-2540	CORK BORER, set of 6, 1/2" largest borer	set	6.20
28-2560	COTTON, absorbent, not sterilized	lb.	.90
28-2600	CULTURE DISHES, Petri, Pyrex, 100 mm x 15 mm	pair	.60
17-3380	CUPS, measuring, Set of 4 (1 C, 1/2 C, 1/3 C, 1/4 C)	set	.36
28-2700	CYLINDER, graduated, Tuttle, short form, 100 ml capacity	each	2.70
28-2720	CYLINDER, hydrometer jar, 275 ml capacity, 13-38" high	each	2.40
28-3015	DISHES, evaporating, Coors 430, 75 mm diameter, 30 mm high, 70 ml capacity	each	.47
28-3040	DISSECTING NEEDLE, wooden handle, bent needle	each	.10
28-3050	DISSECTING NEEDLE, wooden handle, straight needle	each	.07
28-3100	DROPPER, medicine, (12 to pkg)	pkg.	.46
28-3140	DROPPING BOTTLE, 30 ml	each	.35
59-0130	DRY CELL, 1½ volt, #6, diameter 2-1/2", height 6"	each	.64

BASIC SCIENCE SUPPLIES FOR ELEMENTARY SCHOOLS

Item No.		Unit	Unit Price
28-3200	ELECTRIC PLATE, 3 heat, 1000 watt, 110 volt	each	6.14
28-3240	ELECTROMAGNET, horseshoe type	each	11.40
28-3260	ELECTROSCOPE, flask form, 250 ml, Pyrex Erlenmeyer flask	each	2.85
28-3280	ETHYL ACETATE, for killing insects	lb.	1.26
28-3300	FEHLING'S SOLUTION, A	16 oz bottle	1.20
28-3320	FEHLING'S SOLUTION, B	16 oz bottle	1.55
28-3400	FILE, Triangular, 4"	each	.38
28-3500	FILTER PAPER, qualitative, 100 circles per package, 11 cm diameter	pkg.	.44
28-3600	FLASK, Erlenmeyer, narrow mouth, Pyrex, 250 ml	each	.48
28-3620	FLASK, Erlenmeyer, narrow mouth, Pyrex, 500 ml	each	.61
28-3800	FUNNEL, plastic, 73 mm, or 2-7/8" top diameter	each	1.14
28-4000	FUNNEL, Pyrex, 65 mm or 2-1/2" top diameter	each	.75
28-4100	FUNNEL, thistle top, 30 cm or 12" length, 35 mm or 1-1/4" diameter	each	.36
	GLOVES, rubber:		
28-4120	size 8	pair	.80
28-4130	size 9	pair	.80
28-4140	size 10	pair	.80
28-4200	GYROSCOPE, simple form, 5.5 cm diameter, support and starting cord	each	1.25
28-4360	HYDROCHLORIC ACID (HCL)	lb.	1.03
28-4400	HYGROMETER, Humidiguide, direct reading	each	9.00
28-4500	IRON FILINGS	1# carton	.38
28-4600	JAR, battery, cylindrical, 1 gallon	each	1.42
28-4800	LAMP, incandescent, miniature, 2-1/2 volt maximum, screw base	each	.25
28-4805	LENSES, demonstration set, 3.75 cm diameter, 6 in set	each	5.25
28-4810	LIME WATER TABLETS (See Calcium Hydroxide Solution, #28-2010)	each	.0075
28-4820	LITMUS PAPER, blue, 100 strips in vial	vial	.09
28-4840	LITMUS PAPER, neutral, 100 strips in vial	vial	.09
28-4860	LITMUS PAPER, red, 100 strips in vial	vial	.09

Item No.		Unit	Unit Price
28-4940	MAGNETS, bar, steel, 2 in box with keepers	set	1.80
28-5100	MAGNETS, ceramic cylinders, 3/8" x 1/8", #1054	each	.03
28-5000	MAGNETS, ceramic cylinders, .52" x .25", #866	each	.03
28-5140	MAGNETS, "floating"	each	3.25
28-5200	MAGNETS, horseshoe, 2.8 cm	each	.60
28-5240	MAGNETS, horseshoe, 4 cm	each	2.20
28-5250	MAGNETS, natural, lodestone	each	.22
28-5260	MAGNETIC NEEDLE, on stand	each	2.45
28-7100	MAGNIFIER, round, 3" diameter reading glass with handle, 2x to 3x	each	1.25
28-5300	MAGNIFIER, small, premium plastic, 3-5/8" long, fitted with two spherical convex lens (3x and 7x) and two cylindrical magnifiers	each	.31
28-5280	MAGNIFIER, tripod, 10x	each	1.10
28-5320	MAT, asbestos, 10" x 16"	each	.65
28-5340	MAT, wire gauze, asbestos center, 4 inch	each	.21
28-5380	METER STICK, maple, metric and English scales	each	.85
28-5400	MICROSCOPE, ELECTRIC, including: 50X and 100X objectives, 12 prepared slides, micromount cards, one 32 page booklet, "The Microscope in Elementary Science", and wood case	each	18.18
18-4600	ELECTRIC LIGHT BULB, 6 watt, 115 volt, candelabra bayonet base (replacement bulb for item #28-5400)	each	.18
28-5410	MICROSCOPE, model ESM, 100X Bausch and Lomb (No Sub) Cat. 31-33-03 (Price includes illuminator, item #28-5425)	each	15.00
28-5420	MICROSCOPE, ZOOMSCOPE, Model STZ 100 Bausch and Lomb (No Sub) Cat. 31-21-03 Magnification 25x through 100 x Zoom. (Price includes illuminator, item #28-5425)	each	53.00
28-5425	ILLUMINATOR, portable, Bausch and Lomb (No Sub) Cat. 31-33-03 Rite-Lite	each	3.00
28-5426	LAMP, replacement for microscope illuminator (Rite-Lite) Item #28-5425, 9-3/4 watt, candelabra, screw base, Bausch and Lomb, (No Sub) Cat. 31-31-40	each	.15
28-5500	MICROSCOPE SLIDES, culture	each	.12
28-5600	MICROSCOPE SLIDES, plain, 72 per box	box	1.10
28-5700	MIRROR, concave and convex, 75 cm diameter, 20 cm focus	each	1.00
28-5740	MIRROR, plane, square, 10 cm x 10 cm	each	.20
28-5800	MORTAR AND PESTLE, porcelain, Coors 522, 100 mm diameter, 60 mm high, 115 mm pestle length	set	1.66
28-5840	MOTOR, St. Louis, with 2 bar magnets; electromagnet attachment, $6.15	each	13.50

Item No.		Unit	Unit Price
28-5860	NEEDLES, DARNING, 10 in pkg.	pkg.	.25
28-5880	NEEDLES, KNITTING, 12 in pkg.	pkg.	.55
28-5900	PAN, Dissecting, 12" x 7-1/2" x 5/8" deep	each	1.20
28-5910	PAN, METAL, vitreous enamel, 16-3/8" x 10" x 2-1/8"	each	2.50
28-5920	PAN, METAL, vitreous enamel, 20-1/2" x 12-3/4" x 2-3/8"	each	3.64
28-5930	PAPER, BLUEPRINT, 5 x 7, 24 sheets	pkg.	.49
28-5940	PAPER, BLUEPRINT, 8 x 10, 24 sheets	pkg.	1.29
28-5960	PINS, SILK, #2, for mounting insects (100 per pkg.)	pkg.	.43
28-5980	PITH BALLS, 12	pkg.	.80
28-6100	PLANT FOOD, "Plantabbs", 100 in pkg.	pkg.	.20
28-6000	PLANETARIUM, Universal, shows day and night, seasons, length of day, phases of moon, earth-sun-moon phases, includes manual	each	24.00
28-6200	PLATES, glass, flat, 12 to pkg. 2" x 2" x 1/16" thick	pkg.	.30
28-6220	POTS, FLOWER, unglazed earthenware, 4" diameter	each	.10
28-6240	PRISM, equilateral, flint glass, 75 mm long	each	2.00
28-6300	PULLEY, double, Bakelite	each	1.15
28-6340	PULLEY, single, Bakelite	each	.80
28-6400	PULLEY, double tandem, Bakelite	each	1.55
28-6440	PULLEY, triple tandem, Bakelite	each	2.05
28-6500	PUMP, model, plastic, force	each	5.65
28-6540	PUMP, model plastic, lift	each	4.95
28-7000	RADIOMETER	each	.80
28-7140	RECEPTACLE, screw base, for incandescent lamp, miniature, item #28-4800 (unmounted)	each	.25
28-7145	RECEPTACLE, screw base, for incandescent lamp, miniature, (mounted on board with Fahnestock clips for easy connection) -- 2 lamps included	each	.94
28-7020	RAIN GAUGE, wedge shape	each	3.95
28-7300	ROD, FRICTION, glass, 300 mm x 13 mm	each	1.10
28-7340	ROD, FRICTION, hard rubber, 250 mm x 13 mm	each	.70
28-7360	ROD, soft iron (used as electromagnet core)	each	.25
28-7400	RUBBER STOPPERS, assorted sizes, 00-8 (solid, one-hole and two-hole)	2 lb.	2.40

Item No.		Unit	Unit Price
17-5800	SALT SHAKER, glass, for iron filings	each	.08
28-7480	SCALE, balance, spring dial type, 250 gms or 9 oz. capacity, Cenco 5410 - or equal, (to determine the weight of objects weighing less than one-half pound and small forces)	each	2.25
28-7490	SCALE, balance, spring, dial type, 500 gms or 18 oz. capacity, Cenco 5510 - or equal, (to determine the weight of objects weighing one pound or less and to measure small forces)	each	2.25
28-7500	SCALE, balance, spring, dial type, 2,000 gms or 72 oz. capacity	each	2.25
28-8000	SCIENCE KIT AND MANUAL, contains almost all necessary initial equipment for elementary science	each	42.00
28-8040	SILK PAD, exciting	each	.55
28-8200	SPOON, DEFLAGRATING, iron, 3/4" diameter cup, total length 15"	each	.26
28-8300	SUPPORT, iron, rectangular base, 4-7/8" x 8", w/rod	each	1.90
	SUPPORT, ring with clamp		
28-8400	2-1/2" inside diameter	each	.95
28-8500	3-3/8" inside diameter	each	1.05
28-8520	SWITCH, KNIFE (unmounted) single pole, single throw	each	.40
28-8525	SWITCH, KNIFE (mounted on board with Fahnestock clips for easy connection) single pole, single throw	each	1.13
59-0570	SWITCH, PUSH BUTTON (unmounted)	each	.50
28-8530	SWITCH, PUSH BUTTON (mounted on board with Fahnestock clips for easy connection)	each	1.08
28-8600	TELEPHONE RECEIVER	each	5.00
28-8640	TELEPHONE TRANSMITTER	each	4.00
28-8700	TEST TUBES, Pyrex, 6" x 5/8"	each	.0508
28-8740	TEST TUBE CLAMP (Holder)	each	.11
28-8800	TEST TUBE RACK, wood, 6 holes and 6 pins	each	.70
28-9000	THERMOMETER, Celsius, (Centigrade) laboratory type, (-10°C to 110°C)	each	1.80
28-9005	THERMOMETER, Celsius, (Centigrade) student type, (-30°C to 50°C) inexpensive thermometer mounted on plastic backing	each	.15
28-9040	THERMOMETER, Fahrenheit, laboratory type, (0°F to 230°F)	each	1.40
28-9050	THERMOMETER, Fahrenheit, student type	each	.15
28-9100	THERMOMETER, metal, protected bulb, white enamel, scale in black	each	1,08
28-9200	THERMOMETER, outdoor, metal, protected bulb, mounting brackets, swivel type	each	1.53
28-9300	THERMOMETER, wooden back, natural finish	each	1.20

Item No.		Unit	Unit Price
16-3420	THREAD, black No. 50	spool	.09
16-3520	THREAD, white No. 50	spool	.09
28-9340	TONGS, beaker, Fisher improved	pair	6.50
28-9360	TONGS, crucible, Parkerized steel	pair	.38
	TOOLS:		
32-4740	HAMMER, claw, 10 oz. head	each	2.24
28-4300	HAMMER, geologist, 22 oz. head	each	5.50
32-6300	PLIERS, combination, adjustable, 6"	each	.50
32-7460	SAW, HACK, adjustable	each	1.18
32-0930	BLADE, HACKSAW, 12", 14 teeth	each	.10
32-7550	SCREWDRIVER, 4" blade, Stanley #20	each	.71
32-8750	SHEARS, tinners snips, 3" cutting length, Wiss #9	pair	2.29
28-9400	TUBING, GLASS, lead-potash, 6 mm outside diameter	lb.	.55
28-9420	TUBING, RUBBER, 3/16", black	ft.	.27
28-9440	TUBING, RUBBER, 3/16", red	ft.	.27
	TUNING FORK, unmounted		
28-9500	128 vps	each	5.50
28-9520	256 vps	each	5.50
28-9540	320 vps	each	5.15
28-9560	384 vps	each	5.15
28-9580	512 vps	each	5.00
15-9200	TWEEZER, length - 4-5/8"	each	.31
12-8600	VERMICULITE	5# bag	.20
28-9600	VOLT-AMMETER, pocket type, DC, range 0-10 volts, 0-35 amperes	each	3.60
28-9640	WATCH GLASS, Pyrex, 75 mm diameter	each	.15
28-9700	WEATHER VANE, with base, metal, directions plainly marked	each	.83
28-9720	WEIGHTS, BALANCE, AVOIRDUPOIS, iron, class T, 1/2 oz. to 1 lb. (set of 8)	set	5.00
28-9740	WEIGHTS, METRIC, HOOKED, 10 gm - 1 kgm	set	14.25
28-9750	WEIGHTS, BALANCE, METRIC, in wood block, 1 gm - 500 gm	set	8.25
28-9770	WIRE, copper, annunciator, #22, vinylite covered	1# coil	2.34
28-9780	WIRE, iron, 17 gauge	4 oz spool	.34
28-9800	WOOD SPLINTS, 500	pkg.	.63

Item No.		Unit	Unit Price
	BIRD CARDS, Audubon, postal card size, 50:		
28-1100	Summer	box	1.20
28-1200	Winter	box	1.60
28-1300	Spring	box	1.60
28-1400	BIRD CHARTS, Audubon, 20" x 30", set of 4: Winter, Summer, Game Birds, and Birds of Prey	set	3.55
28-7200	ROCK CYCLE CHART	each	10.95
	ROCK COLLECTION:		
28-7210	KINDERGARTEN, 5 specimens to illustrate the Kindergarten concepts, each 3" x 3" x 2" (unmounted)	set	1.40
28-7220	GRADE ONE, 9 specimens to illustrate the First Grade concepts, each 3" x 3" x 2" (unmounted)	set	1.40
28-7230	GRADE FOUR, 9 specimens to illustrate the Fourth Grade concepts, each 3" x 3" x 2" (unmounted)	set	1.40

(Schools may purchase emergency supplies directly, paying for same out of the school building's funds. Principals are requested to accumulate receipts of at least five dollars ($5.00) and then make a general requisition (form G1000) to cover the items purchased. Attach all receipts and send the requisition to the Finance Department for reimbursement from the individual school's supply allotment.)